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PICKERING NGS - INSPECTION OF STEEL BULKHEAD AND CONCRETE BETWEEN THE SPENT FUEL STORAGE BAY AND SPENT FUEL TRANSFER DUCT - UNITS 1 & 2

Report No. 90-252-K

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ABSTRACT

The bulkhead separating the Spent Fuel Storage Bay and Spent Fuel Transfer Duct was inspected to assess its condition and to identify the source of water leakage occurring from the bay into the duct. The inspection consisted of visual observations and sounding of the concrete surfaces around the bulkhead. Based on the inspection, water leakage appears to originate around the embedded steel angle and concrete surface surrounding the periphery of the steel bulkhead. The major source of water leakage estimated to be approximately 10-20 L/h originates along the north wall. Minor leakage was observed along the south wall and the roof. Based on the inspection, repairs to the bulkhead were recommended. To optimize on the repair materials and techniques, full-scale models of the bulkhead were constructed and the successful repair process was demonstrated. Recommended procedures for carrying out the repair to the bulkhead are included in this report.

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PICKERING NGS - INSPECTION OF STEEL BULKHEAD AND CONCRETE BETWEEN THE SPENT FUEL STORAGE BAY AND SPENT FUEL TRANSFER DUCT - UNITS 1 & 2

1.0 INTRODUCTION

At the request of Pickering Operations, a limited inspection was carried out to assess the condition of the steel bulkhead and concrete separating the Spent Fuel Storage Bay (SFSB) and the Spent Fuel Transfer Duct (SFTD). Water has been observed on the concrete floor at the base of the bulkhead and along the floor in the Spent Fuel Transfer Duct. This inspection was carried out to establish the location and cause of water leakage, as well as the need for any repair.

In order to determine the source of water leakage, the following was carried out:

a) Visually inspected accessible areas inside the SFTD at the SFSB bulkhead.

b) Examined the steel and concrete surface for any signs of cracking or separation.

c) Sounded concrete surface for any spalling or honeycomb areas around the bulkhead.

This report summarizes the results of the inspection, full-scale mockup for testing of the repair materials and techniques, and recommended procedures for carrying out the repair.

2.0 STEEL BULKHEAD CONFIGURATION

The configuration of the bulkhead is shown in Figure 1. A ½" stainless steel plate is welded to L 3 ½" x 3 ½" steel angles embedded in the concrete. On the SFTD side, a ½" x 6" long plate bracing is welded to the back of the bulkhead to act as a stiffener.

3.0 INSPECTION OF BULKHEAD

As a result of the high radiation fields, only limited time was available to inspect the bulkhead. An inspection of the accessible areas around the bulkhead/concrete interface revealed the following:

a) There was no evidence of any deterioration or leakage through the steel bulkhead, although the surface of the steel was discoloured (Figure 2).

b) No water leakage was noted around the conveyor pulley assembly (Figure 3).

c) There was no evidence of any cracking, spalling or honeycombing in the concrete at accessible areas (Figures 2 and 4).

d) Water leakage was observed between the steel bulkhead and concrete; however, it was not possible to inspect this area closely because of available time and limited access (ie, location of stiffener plates on steel bulkhead). It is speculated that the water leakage may be originating around the steel angle embedment at the concrete interface (Figure 1).

e) Along the entire roof of the duct and limited areas on the south wall, the concrete surface was damp (Figure 2). The main source of water leakage is along the north concrete wall (Figure 4). Along this wall, the cement paste on the surface of the concrete has eroded due to contact with the de-ionized water. The rate of water leakage appears to be small (ie, 10 - 20 L/h) and is well below that estimated by the Nuclear Engineering Department (ie, 80 - 100 L/h).

f) There were no signs of cracking or deterioration around the bulkhead on the SFSB side (Figure 5).

4.0 FULL-SCALE TEST MODELS OF SFSB/SFTD BULKHEAD

To stop the leakage of the contaminated (radioactive) water and to prevent deterioration of the concrete/steel interface, it was recommended that repairs be undertaken. Two full-scale models of the bulkhead were constructed to:

a) Verify the performance characteristics of the epoxy resins (ie, flowability, water displacing characteristics, maximum temperature rise, etc.)

b) Assess the procedures for installation and the performance characteristics of the temporary bulkhead. This bulkhead is required to seal the surface of the void between the concrete and stiffener plates, to allow for epoxy injection of the void.

c) Provide a test model for construction and operations to carry out a dry run of the actual repair and optimize the repair technique. The dry run should reduce the actual time of carrying out the repair and minimize radiation exposure to workers.

5.0 ASSESSMENT OF EPOXY INJECTION RESINS

Initial tests were carried out to assess the physical characteristics of two epoxies (ie, tack and hard times, maximum temperature rise, compressive strength). Each epoxy had quite different characteristics in the fresh state.

Capweld 624 - long pot life, very low viscosity and good water displacing characteristics to ensure maximum penetration of the leakage zone and subsequent filling of the larger void.

Capweld 624 Thixotropic - short pot life, high viscosity and good water displacing characteristics to provide a dam at the base of the steel bulkhead/concrete interface to prevent leakage of the low viscosity epoxy.

Tests results are given in Table 1 and revealed the following:

a) Both epoxies developed very high reaction temperatures (ie, >170 °C in 250 mL mass). See Figures 6 and 7 for further details.

b) As a result of these high temperatures, shrinkage of the epoxies occurred upon cooling.

c) Capweld 624 cracked extensively.

d) No cracking occurred in the Capweld 624 Thixotropic epoxy. However, the epoxy expanded and foamed as a result of the low concentrations of moisture in the filler and the high temperature converting the moisture to gas.

e) Other physical characteristics (ie, tack and hard times, density, and compressive strength) were considered acceptable.

Since a relatively large volume of epoxy is required for use in the actual repair, a modification was made to Capweld 624 as follows:

a) 45% of the base resin was replaced with silica flour to reduce the resin content (See Table 1 - Capweld 624LE).

b) By reducing the resin content, the maximum temperature rise was significantly lowered (Table 1), and no shrinkage or cracking of the epoxy was evident.

c) The ratio of resin/filler content was modified so that it would not impede the flowability of the epoxy.

d) The density of the epoxy increased (Table 1), leading to improved water displacing characteristics.

e) Physical characteristics of Capweld 624LE were similar to those of the other two epoxies tested.

Capweld 624LE and Capweld 624 Thixotropic were selected for use in the full-scale mockup trials of the SFSB/SFTD bulkhead.

6.0 CONSTRUCTION AND EPOXY INJECTION OF TEST MODELS

MODEL 1

Details of the construction and epoxy injection of the first model are outlined in Appendix A - Figures A1 to A9 and Table A1. The two epoxies, Capweld Thixotropic and Capweld 624LE, were injected into this model. The main observations noted are as follows:

a) Only one epoxy (Capweld 624LE) is required to fill the void, unless a serious leak develops during the actual repair.

b) Flexible ⅜" tubing used to inject the epoxy resin was not strong enough to prevent bursting of the lines during pressure injection.

c) Epoxy injection through ⅜" tubing is very slow due to frictional resistance in the grout line.

d) Although the epoxy injection rate was slow, the model was successfully injected.

e) Both Capweld 624 Thixotropic and Capweld 624LE easily displaced the water, resulting in virtually no emulsification of epoxy with water. The void was completely filled (Figure 8), with no signs of segregation of the epoxy (Figure 9).

f) The maximum temperature rise of Capweld 624LE was approximately 85 °C (Figure 10)*. There were no signs of shrinkage or cracking in the epoxy, and excellent contact was maintained with the sides and back of the test model. The allowable working time or period of practical use for this epoxy was approximately 45 minutes.

g) Capweld 624 Thixotropic that provided a dam at the base of the model developed a maximum temperature of 156 °C (Figure 10). The material performed adequately, with no cracking and only minor signs of shrinkage. This can be attributed to the relatively small quantity of material injected and the heat sink provided by the cool water. The period of practical use for this epoxy was approximately 20 minutes, and if the time is not properly monitored during injection, it could lead to loss of use of injection equipment.

h) A hydraulic head equivalent to 10 ft of water was maintained on the simulated SFSB side of the model for approximately 24 h. There were no signs of water leakage through the repaired section, showing the effectiveness of the repair technique.

MODEL 2

Model 2 was constructed to simulate the configuration of both the bulkhead and SFTD tunnel. The construction and epoxy injection of this model were similar to those of Model 1, except for the following:

a) 3/8" rigid tubing was used in place of the flexible tubing. Generally, the length of the grout lines was 15 ft, instead of 35 ft.

b) Vent tubes were provided at the roof of the duct to ensure complete displacement of air and water.

c) Generally, epoxy injection was carried out from the base of the void, thus displacing water. However, in one location, the epoxy was allowed to free fall through the water to demonstrate the effect on the epoxy resin.

d) Only one epoxy injection resin (Capweld 624LE) was used to fill the void.

Details of the epoxy injection are outlined in Appendix B - Table B1 and Figures B1 to B5. The main observations made from this model are as follows:

a) Total time to install the temporary bulkhead required for epoxy injection was approximately 30 min.

b) Epoxy injection through rigid 3/8" tubing is still very slow. As a result, 1/2" tubing should be used in the actual repair.

---

* Four thermocouples (1, 2, 3, 4) were installed along the wall (ie, 3", 24" and 40" from base) and roof (centre) at mid-depth of the void.

c) The Capweld 624LE epoxy easily displaced the water (Figure 11) and no emulsification of epoxy with water was evident. Where the epoxy was allowed to free-fall through the water, stratification, emulsification and segregation of the epoxy occurred (Figure 12). This demonstrates the need to ensure that epoxy is properly placed by tremie.

d) Providing vent tubes at the top of the specimen ensured complete filling of the void (Figure 13).

e) A hydraulic head equivalent to 10 ft of water was maintained on the simulated SFSB side of the model for approximately 72 h. There were no signs of water leakage through the repaired section, indicating the effectiveness of the repair technique.

7.0 CONCLUSIONS

Water leakage between the SFSB and SFTD was identified during an inspection of the bulkhead. Repairs to this bulkhead were recommended. As a result, full-scale models were constructed to simulate the SFSB/SFTD bulkhead. These models were successfully repaired by epoxy injection. Based on the laboratory tests, a procedure for repairing the actual bulkhead was prepared and is outlined in Appendix C.

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TABLE 1

PHYSICAL CHARACTERISTICS OF EPOXY RESINS TESTED

Material	Mix Proportions By Mass (Kg)		Tack Time (h)		Hard Time (h)		Period of Practical Use (min) 4-L sample	Maximum Temperature Rise (°C) 250 mL sample	Hardened Density (kg/m³)	Compressive Strength (MPa) Age - Days	
	A Component	B Component	0.200 mm thickness	0.585 mm thickness	0.200 mm thickness	0.585 mm thickness				7	28
Capweld 624	78	28	6.0	5.2	11.5	11.0	-	171	1139	60.3	77.4
Capweld 624 Thixotropic	78	28	4.2	4.0	9.0	8.5	20	179	1135	61.1	72.2
Capweld 624LE	78[1]	28	6.5	5.5	13.5	13	45	33	1619	77.9 77.5[2]	97.5 97.4[2]

Note: All testing carried out at 25°C.

Definition of:

Tack Time: The period between mixing the two components of an epoxy, and the material becoming tacky.
Hard Time: The stage where a reacting liquid epoxy has hardened.

[1] Silica flour is included as part of the A component.
[2] Specimens were made by tremie-ing the epoxy through water in the test moulds.

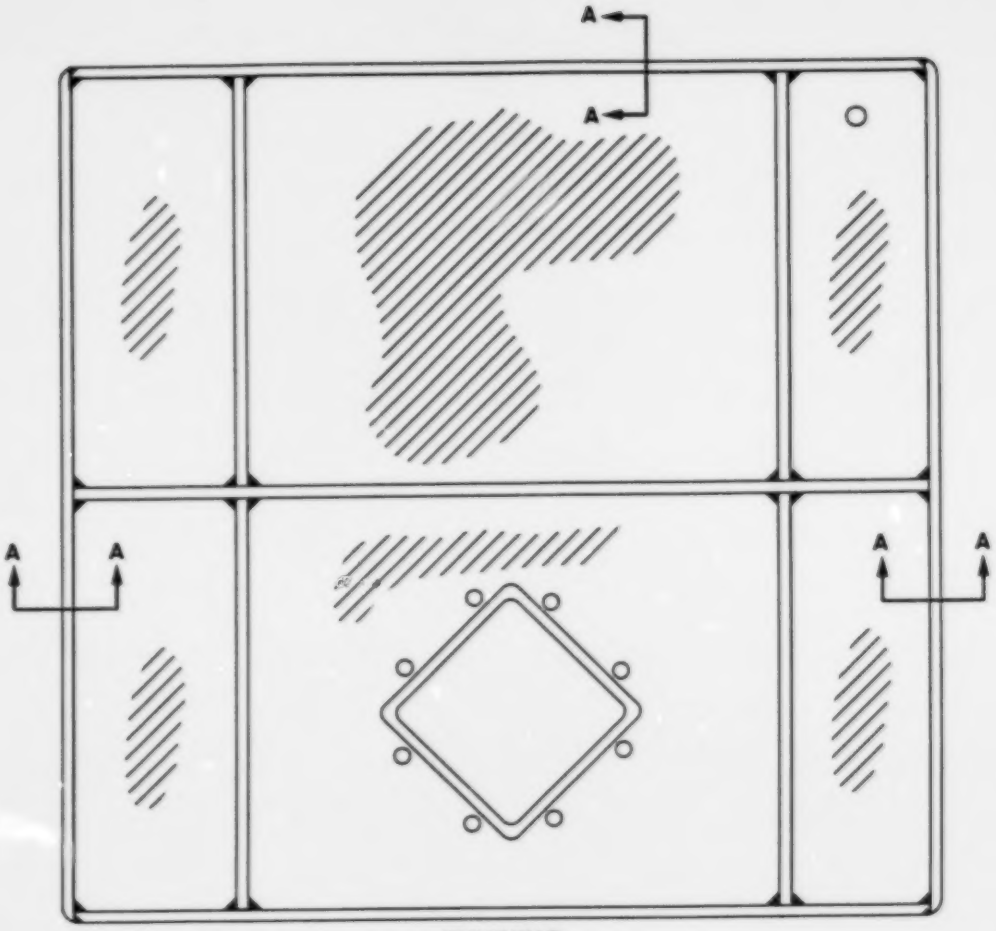
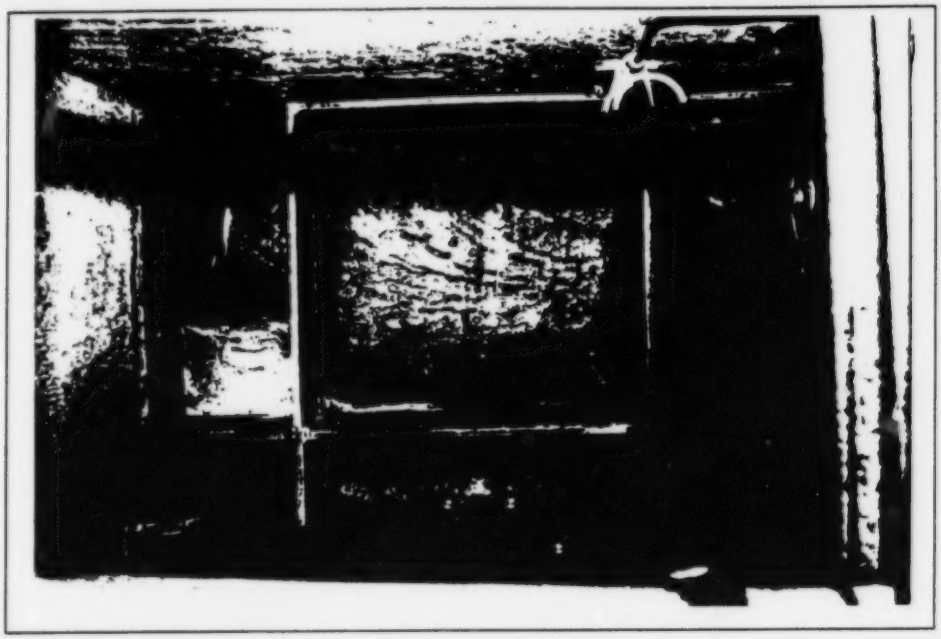


FIGURE 1

CONFIGURATION OF STEEL BULKHEAD SEPARATING SPENT FUEL STORAGE BAY (SFSB) AND SPENT FUEL TRANSFER DUCT (SFTD)

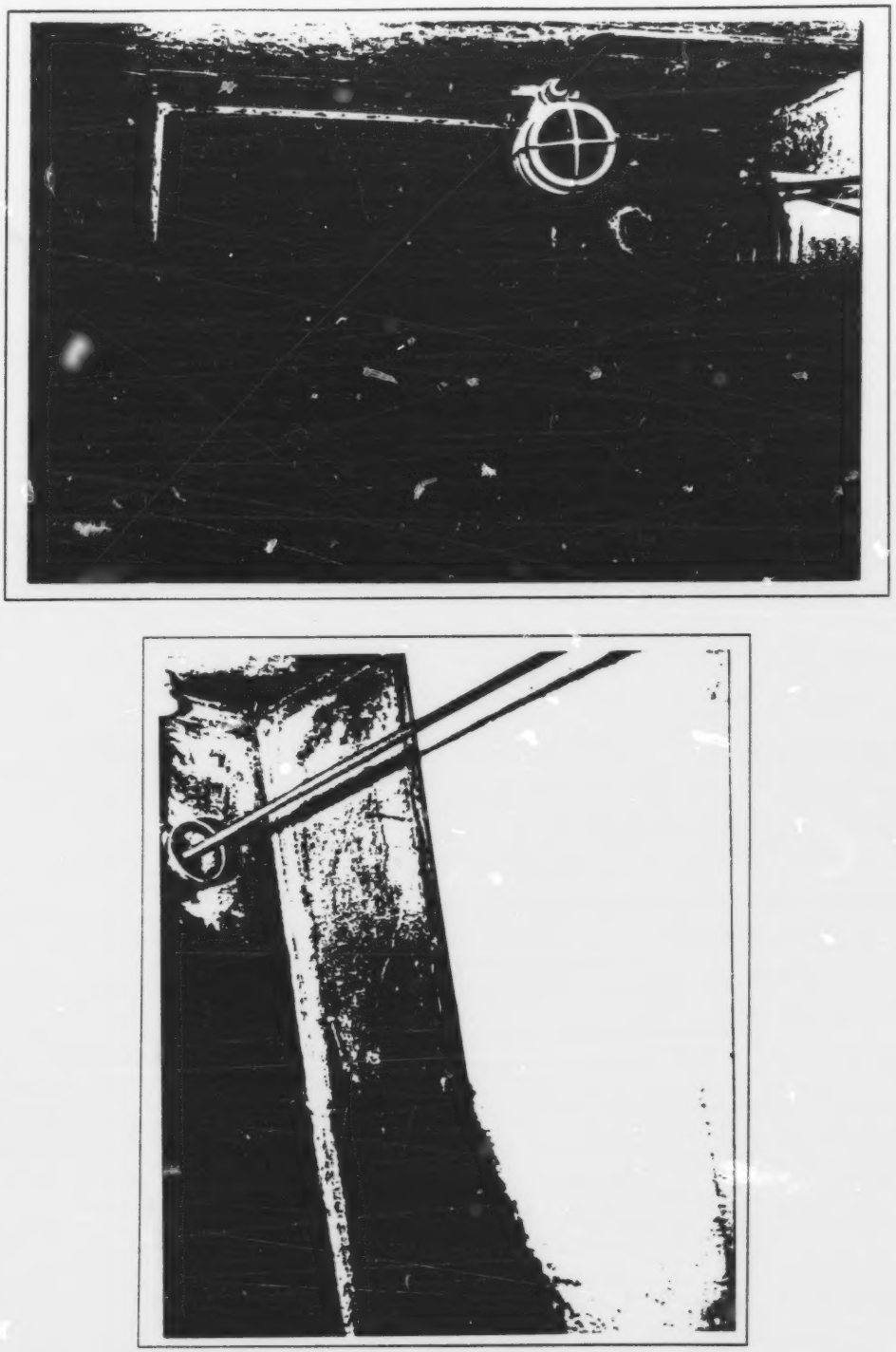


Top of bulkhead
Note surface of concrete at top is wet

Base of bulkhead

FIGURE 2

SPENT FUEL TRANSFER DUCT
VIEW OF TOP AND BASE OF BULKHEAD



No evidence of water leakage
through bulkhead at conveyor pulley assembly

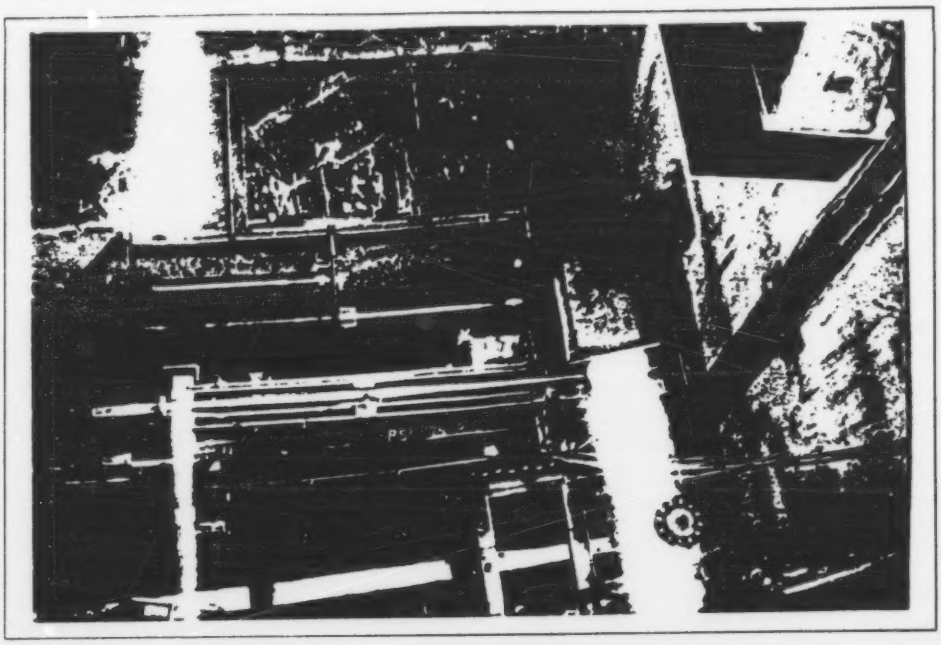
FIGURE 3

SPENT FUEL TRANSFER DUCT
VIEW OF CONVEYOR PULLEY ASSEMBLY - NORTH WALL

Concrete surface wet for 3/4
the height of the North Wall

FIGURE 4

SPENT FUEL TRANSFER DUCT
NORTH FACE - STEEL BULKHEAD CONCRETE INTERFACE



No signs of deterioration at the
stainless steel/concrete interface

FIGURE 5

SPENT FUEL STORAGE BAY
VIEW OF STAINLESS STEEL BULKHEAD

TEMPERATURE RISE OF EPOXY GROUTS

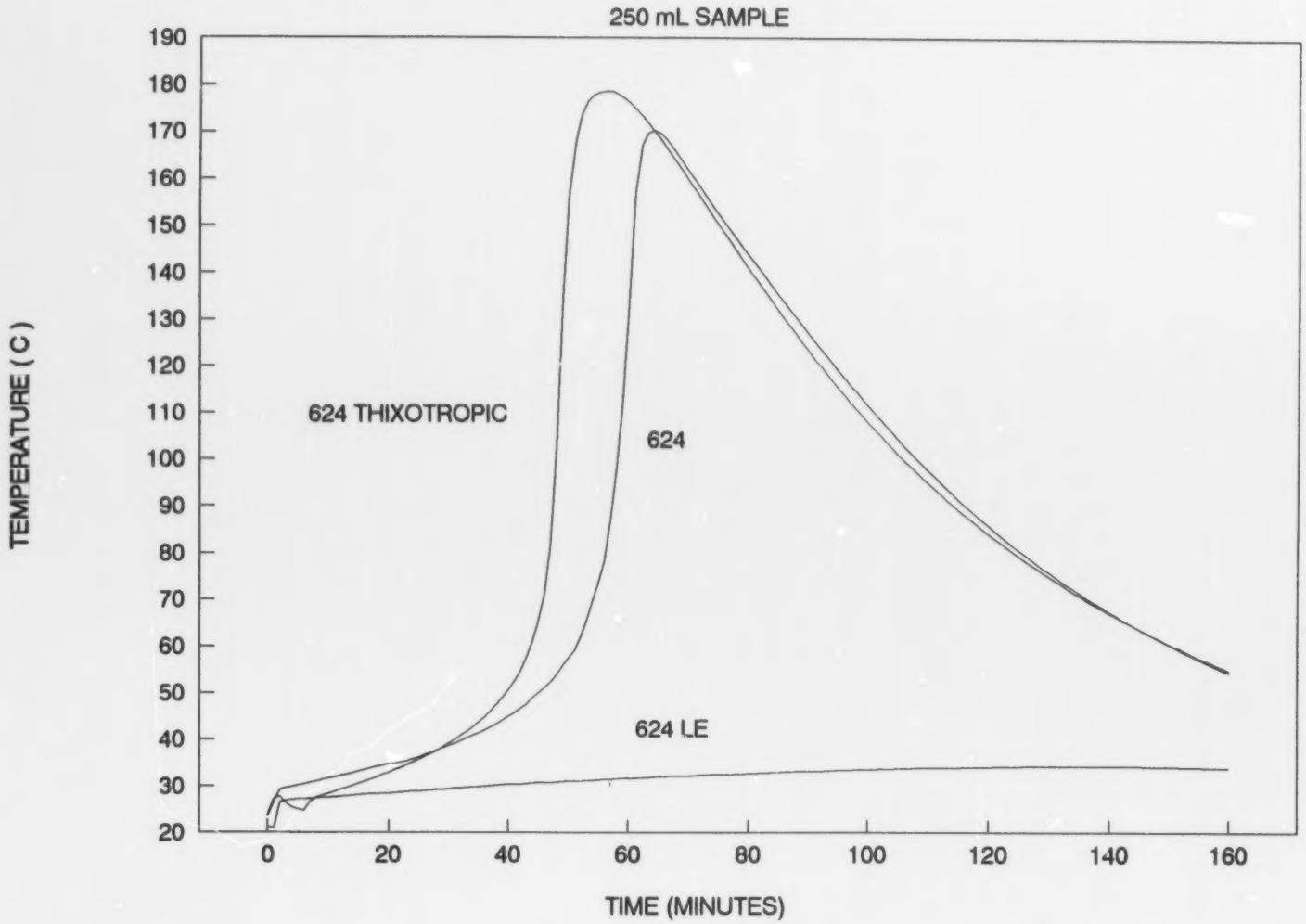


FIGURE 6

TEMPERATURE RISE OF EPOXY GROUTS

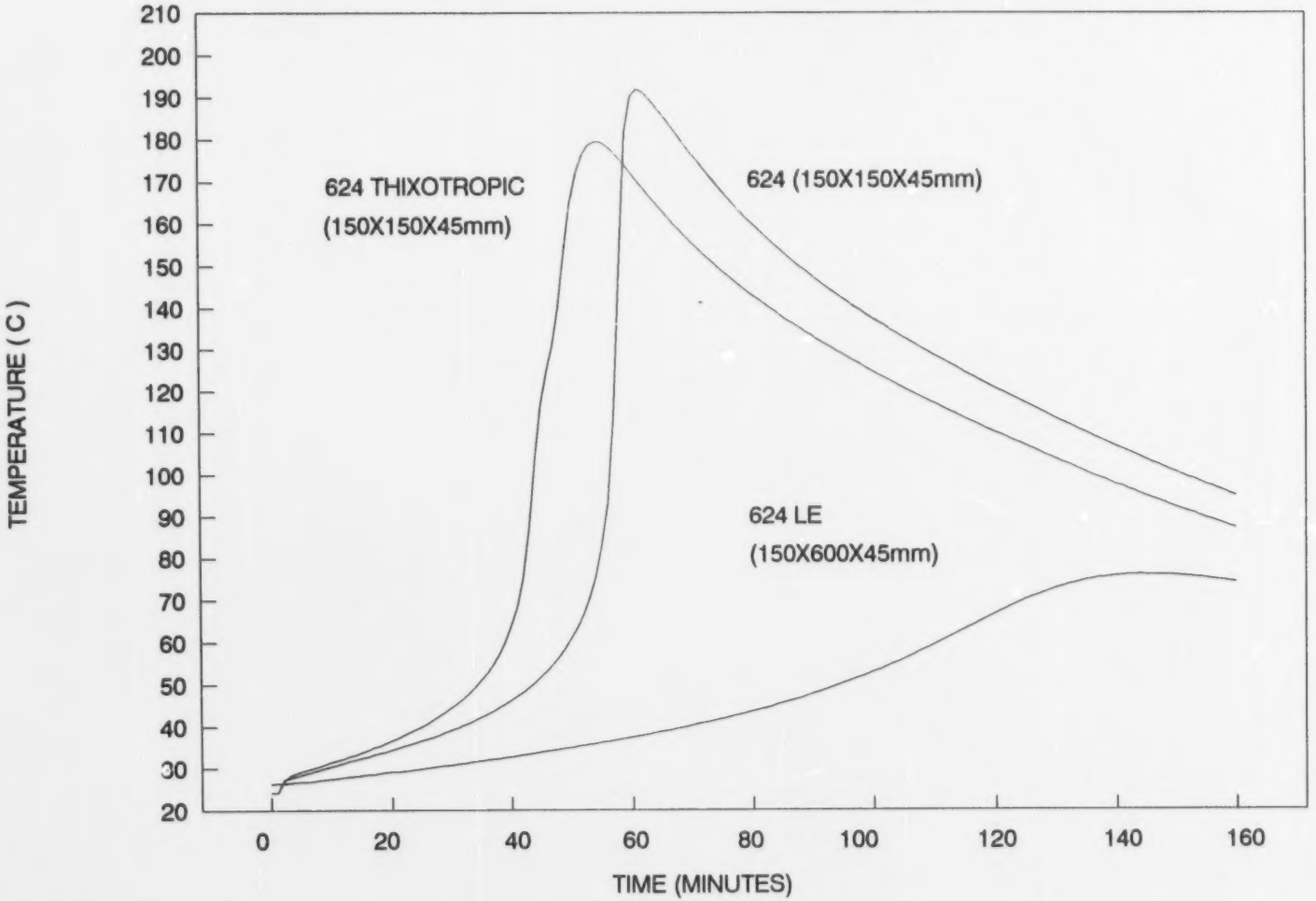
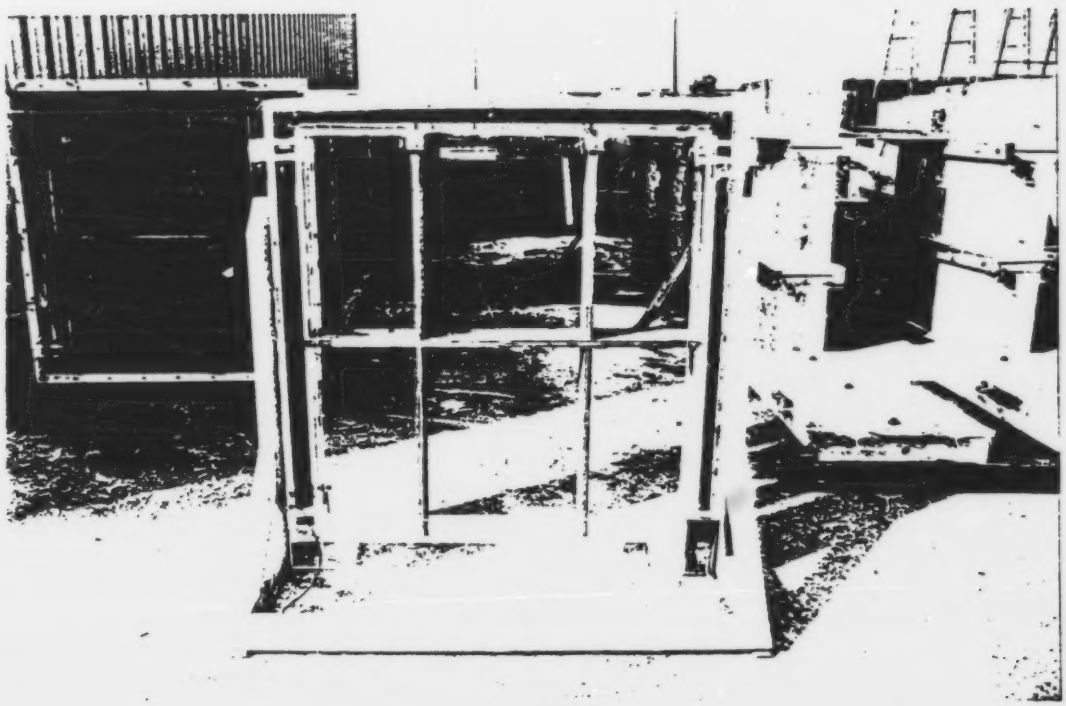


FIGURE 7



Void completely filled with epoxy
No signs of segregation

FIGURE 8

EPOXY INJECTION OF SFSB/SFTD BULKHEAD
MODEL 1

Void completely filled with epoxy
No signs of segregation

FIGURE 9

EPOXY INJECTION OF SFSB/SFTD BULKHEAD
MODEL 1

SFSB/SFTD BULKHEAD MOCKUP

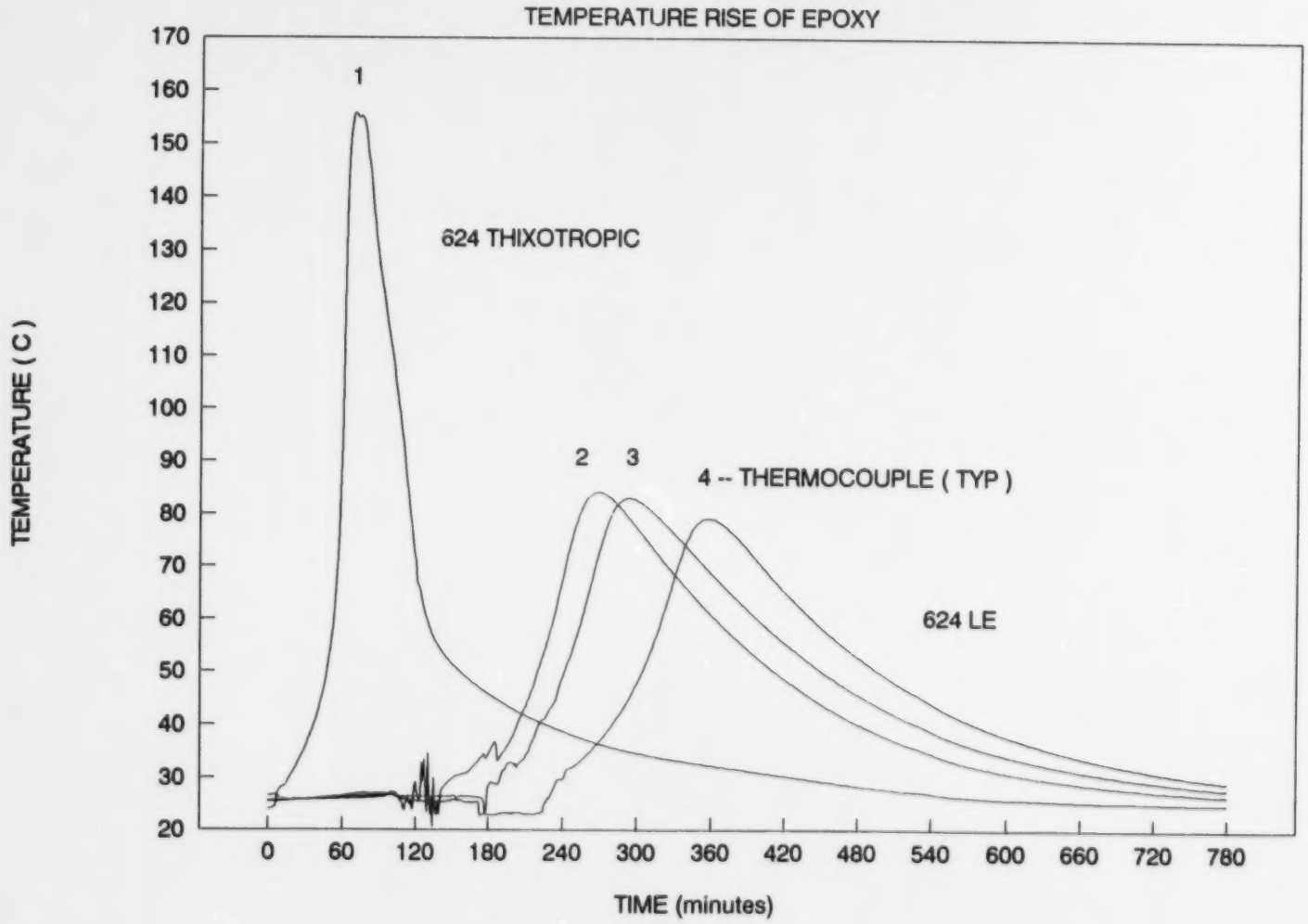
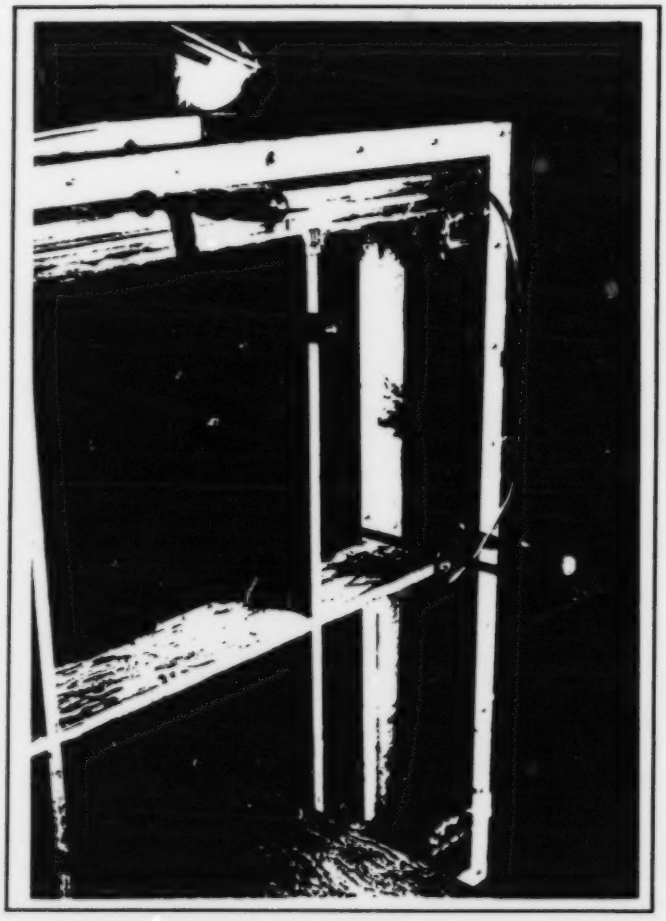


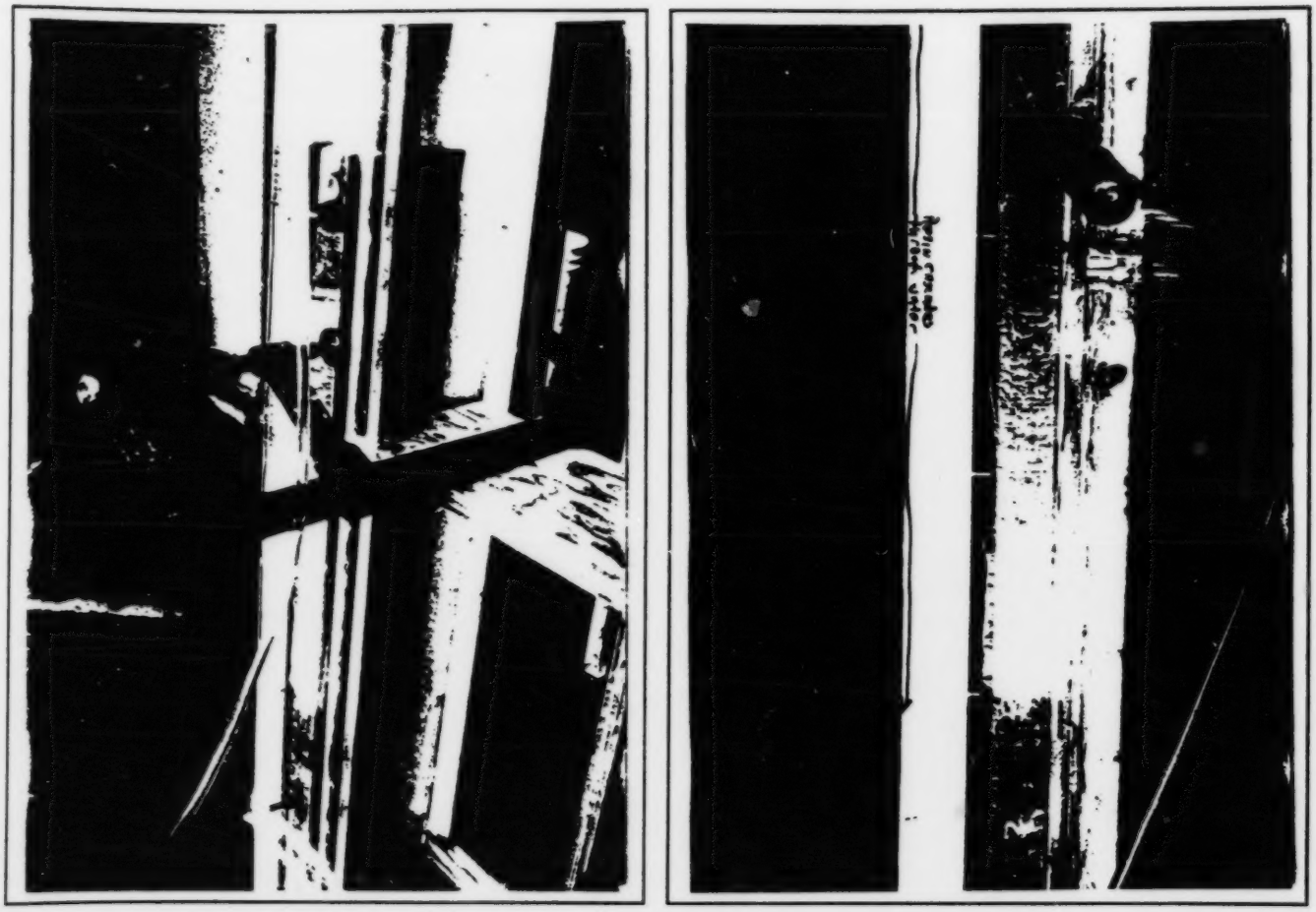
FIGURE 10



Where epoxy resin was placed by tremie, no emulsification of epoxy with water was evident

FIGURE 11

EPOXY INJECTION OF SFSB/SFTD BULKHEAD MODEL 2



Where epoxy was allowed to free-fall through water, stratification, emulsification and segregation occurred

FIGURE 12

EPOXY INJECTION OF SFSB/SFTD BULKHEAD
MODEL 2

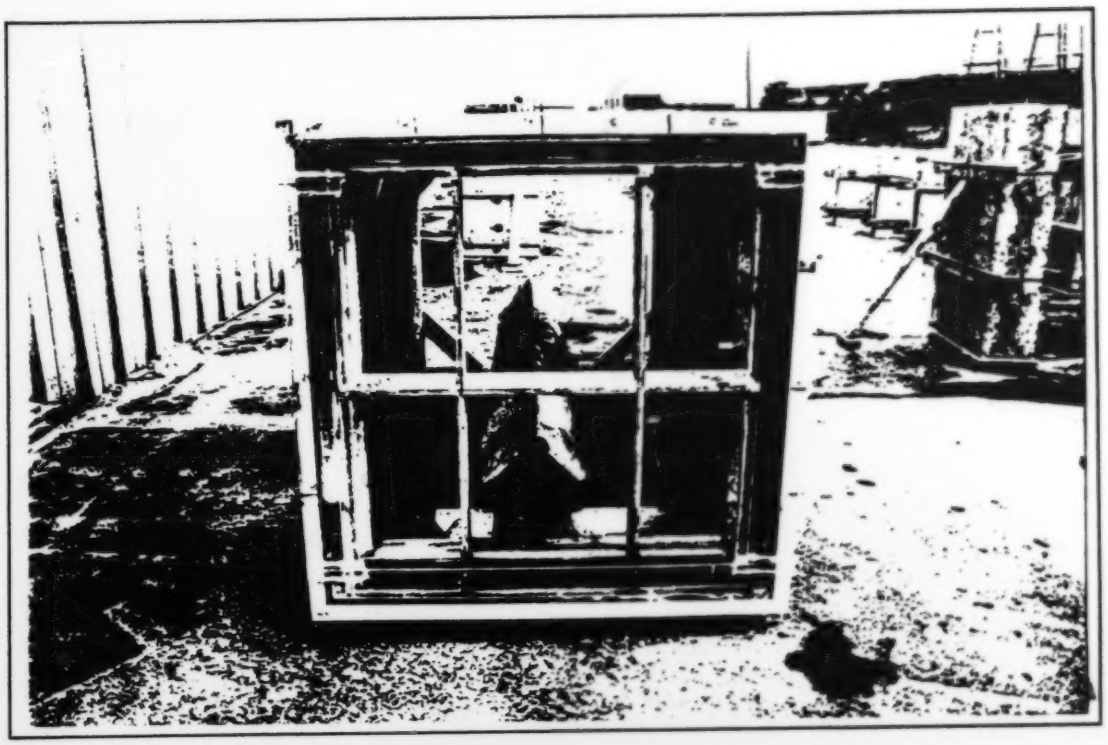


FIGURE 13

EPOXY INJECTION OF SFSB/SFTD BULKHEAD
MODEL 2

APPENDIX A

Full-Scale Model of SFSB/SFTD Bulkhead
Model 1

1.0 Construction and Epoxy Injection of Bulkhead

A full-scale model of the simulated steel bulkhead is shown in Figure A1. The model was constructed of plexiglass in order to visually assess the performance characteristics of the epoxy (ie, pumpability, water displacing characteristics and temperature rise). The procedure followed to construct the temporary seal around the periphery of the bulkhead and to fill the void with epoxy resin is outlined below:

a) Closed cell polyethylene foam (Evazote) was cut into 3 sections to fit into the front face of the void along the walls and roof (Figure A2).

b) The sections of Evazote were welded together using a splicing tool.

c) At predetermined locations, slots were cut into the foam and the foam pierced with a heated ⅜" metal rod to accommodate the installation of injection ports (Figure A3).

d) Evazote was then compressed into the front face of the void using a blunt tool. Evazote was pushed into the void until it was flush with the edge of the stiffener plate (Figure A4).

e) Thirty five feet of clear tubing (⅜" in diameter) was then run to the front face of the bulkhead and attached to the injection ports (Figure A5).

f) Wood bracing with precut slots to accommodate the injection lines was then installed to restrain Evazote (Figure A3).

g) Flowing water was then introduced into the backside of the model (ie, SFSB side) to simulate actual field conditions.

h) Individual injection tubes were connected to the injection equipment (ie, pressure pot). The sequence of connecting the tubes to the pressure pot ensured that the epoxy resin was tremied into place.

i) The two components of the epoxy were individually mixed, then combined and mixed for an additional 3 minutes. The epoxy was then poured into the pressure pot (Figure A6).

j) The pressure pot was sealed and pressurized (ie, pressure varied between 60 to 80 psi). A control valve on the exit side of the pressure pot was then opened to start epoxy injection of the void.

k) Two epoxies were used to fill the void:

   i) Capweld 624 Thixotropic - to create a dam at the base of the north and south wall to prevent leakage of the low viscosity epoxy.

   ii) Capweld 624LE low viscosity epoxy - to fill the void and provide an adequate seal to prevent further water leakage through the bulkhead.

l) Epoxy injection started from the lowest port and proceeded upward. (Figure A7 - A9 and Table A1).

m) After completion of epoxy injection, a hydraulic head of 10 ft was maintained for 24 h to assess the effectiveness of the repair.

TABLE A1
EPOXY INJECTION OF SIMULATED SFSB/SFTD MODEL
(See Figure A7 for further details)

Material	Batch Number	Mixing Time A & B Epoxy Components (min)	Time To Fill Pressure Pot (s)	Time To Fill 3/8" flexible Tubing	Injection Time (min)	Location (See Figure A1)	Injection Pressure (psi)/1/	Measured Height of Epoxy In Model (in)	Remarks
Capweld Thixotropic	1	3	60	540	14	South Wall Port 16	40-60	6	Material required considerable length of time to fill 35 ft of tubing. Epoxy displaced water with no emulsification.
				510	16-1/2	North Wall Port 1	60	4	
					26				Stopped injection. Emptied pressure pot and cleaned out. Within 43 min of mixing, epoxy started to gel.
Capweld 624LE	1	3	30	330	51	North Wall Port 15	40		Mixed Capweld 624LE and filled pressure pot.
					73		70		Capweld 624LE displaced Capweld
					92		70	15	Thixotropic at base of specimen.
					106		70	24	
	2	3	40	310	117	North Wall 13	70	29	Stopped injection. Emptied pressure pot and mixed new batch of epoxy.
					122		70	32	Injection line burst. Moved to Port 12.
					130	North Wall 12		36	At 139 min, stopped and moved to Port 2.
	3	3	30	290	152	South Wall 2		6	Stopped injection. Emptied pressure pot and mixed new batch of epoxy.
					211	South Wall 5		36	Injection line burst. At 229 min, stopped and moved to Port 11 south side.
	4	3	35	340	229	North Wall 11			Stopped injection. Emptied pressure pot and mixed new batch of epoxy.
	5	3	30	330	273				Stopped injection. Emptied pressure pot and mixed new batch of epoxy.
					293				Specimen full.

/1/ Injection pressure measured at pressure pot.

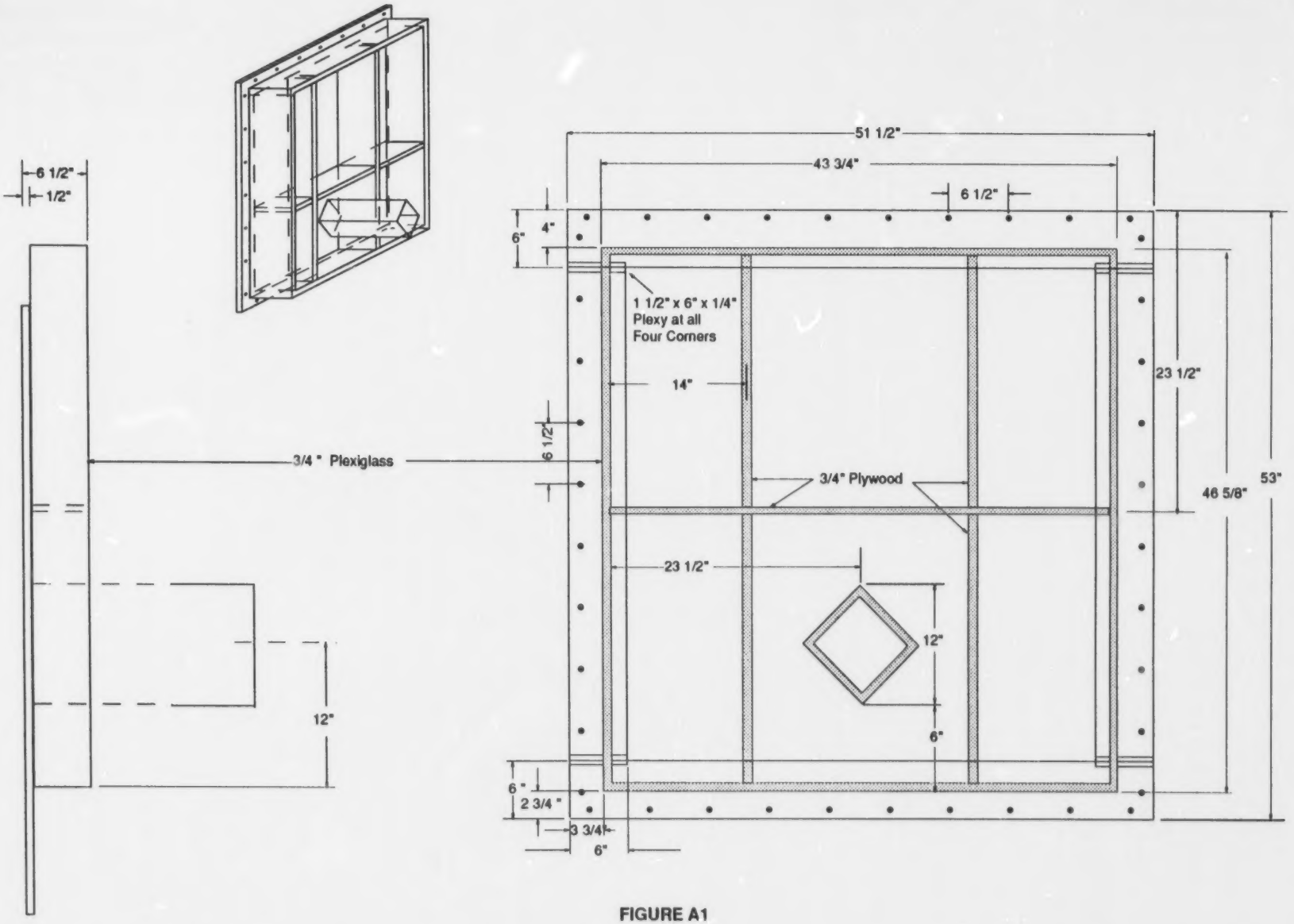
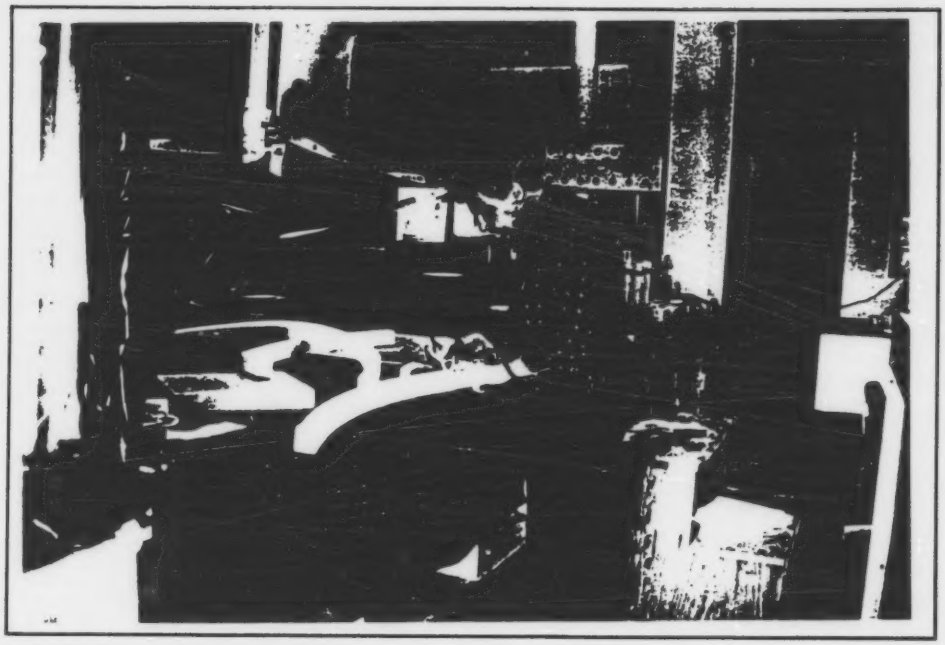


FIGURE A1

FULL SCALE MODEL OF BULKHEAD SEPERATING SPENT FUEL STORAGE BAY AND SPENT FUEL TRANSFER DUCT



Evazote cut into 3 sections to fill the front face
of the void along walls and roof

FIGURE A2

**CLOSED CELL POLYETHYLENE FOAM
(EVAZOTE)**

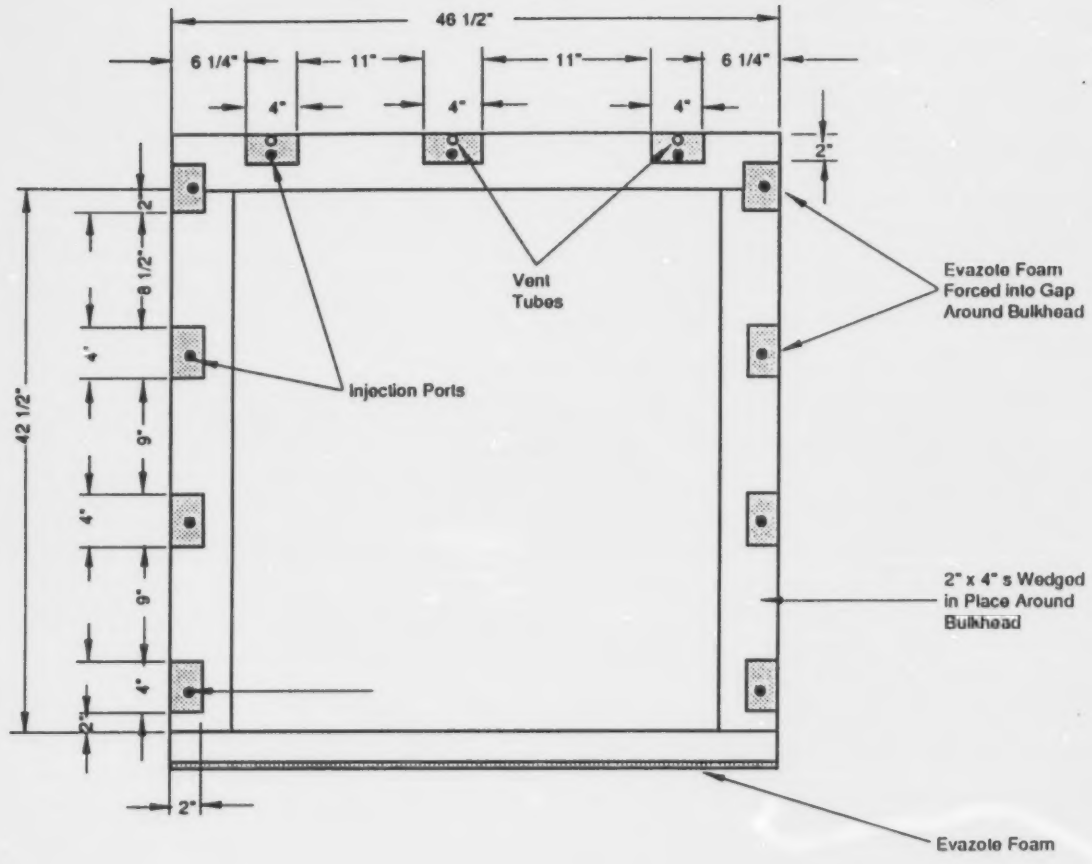
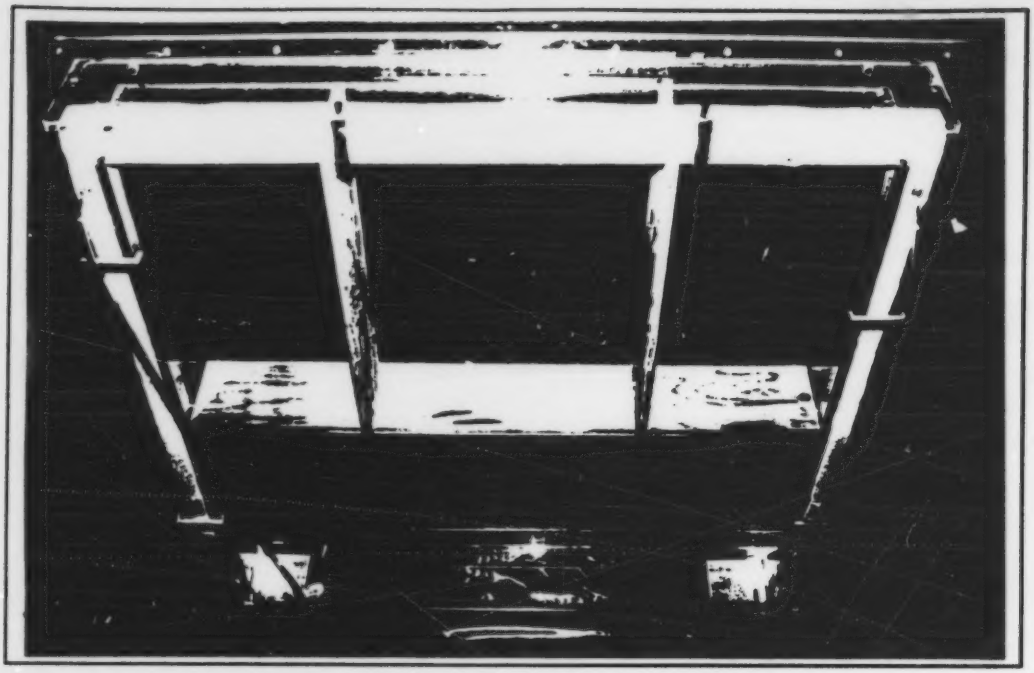
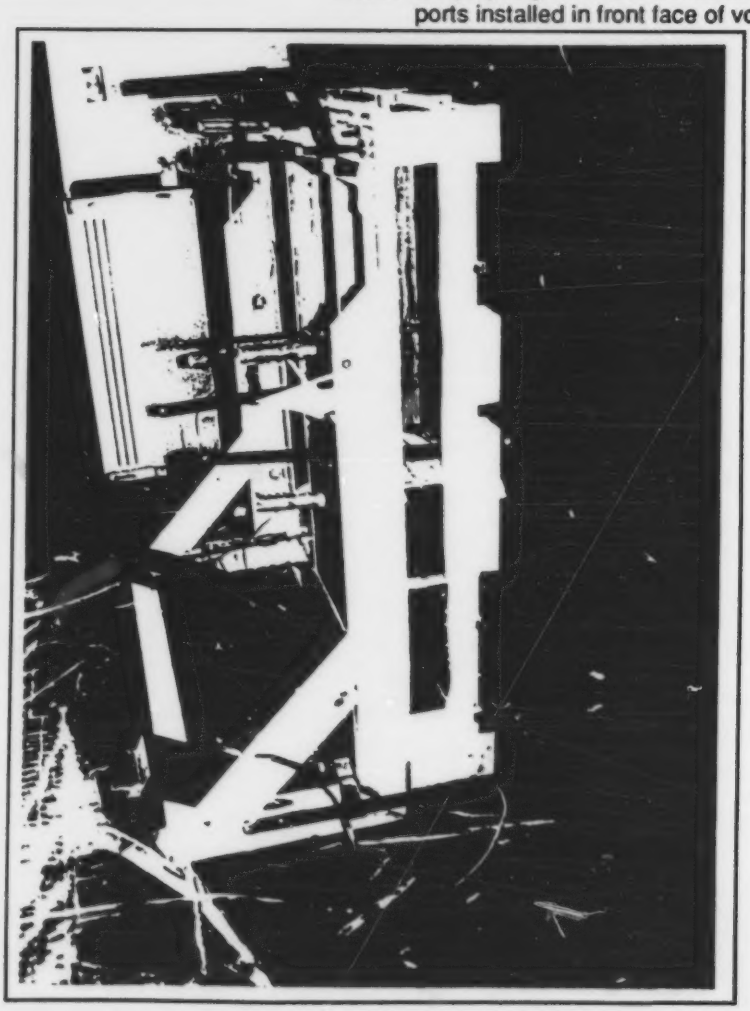


FIGURE A3

DIAGRAM OF INJECTION PORT PLACEMENT IN 2" X 4" FRAME



Closed cell polyethylene foam containing injection ports installed in front face of void



Side view of installed closed cell polyethylene foam and void to be filled with epoxy resin

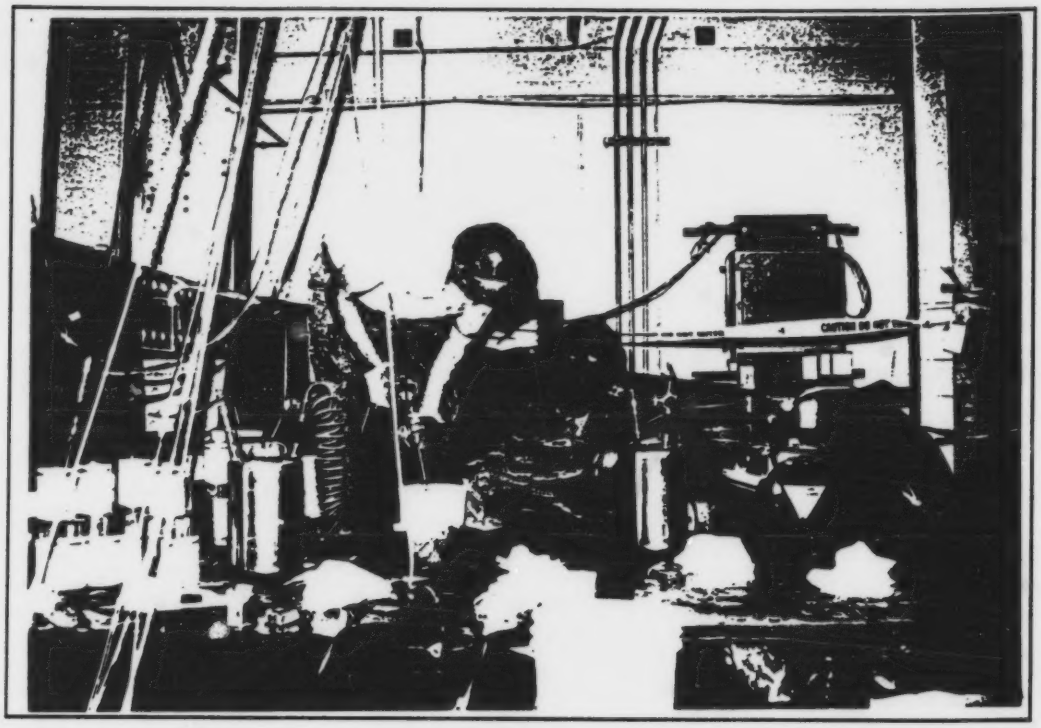
FIGURE A4

FULL-SCALE MODEL OF SFSB/SFTD BULKHEAD

3/8" flexible tubing connected to injection ports

FIGURE A5

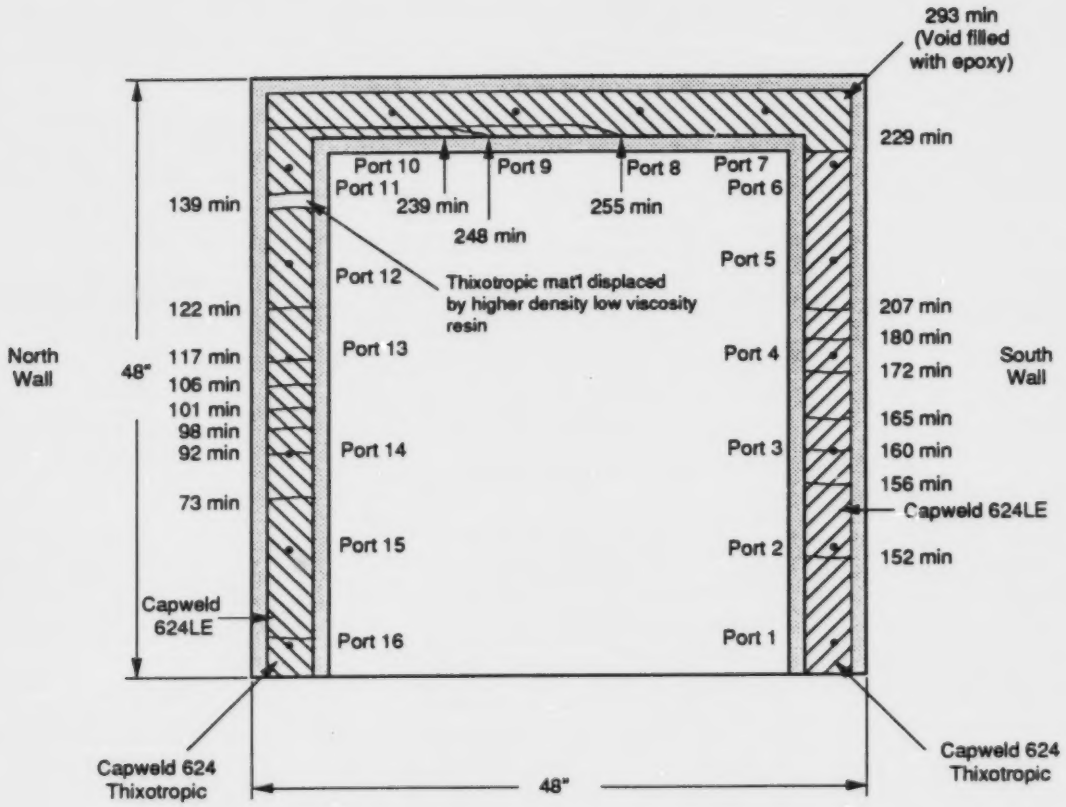
FULL-SCALE MODEL OF SFSB/SFTD BULKHEAD



Two components of epoxy premixed for a minimum
of 3 minutes prior to pouring into pressure pot

FIGURE A6

MIXING OF EPOXY INJECTION RESIN

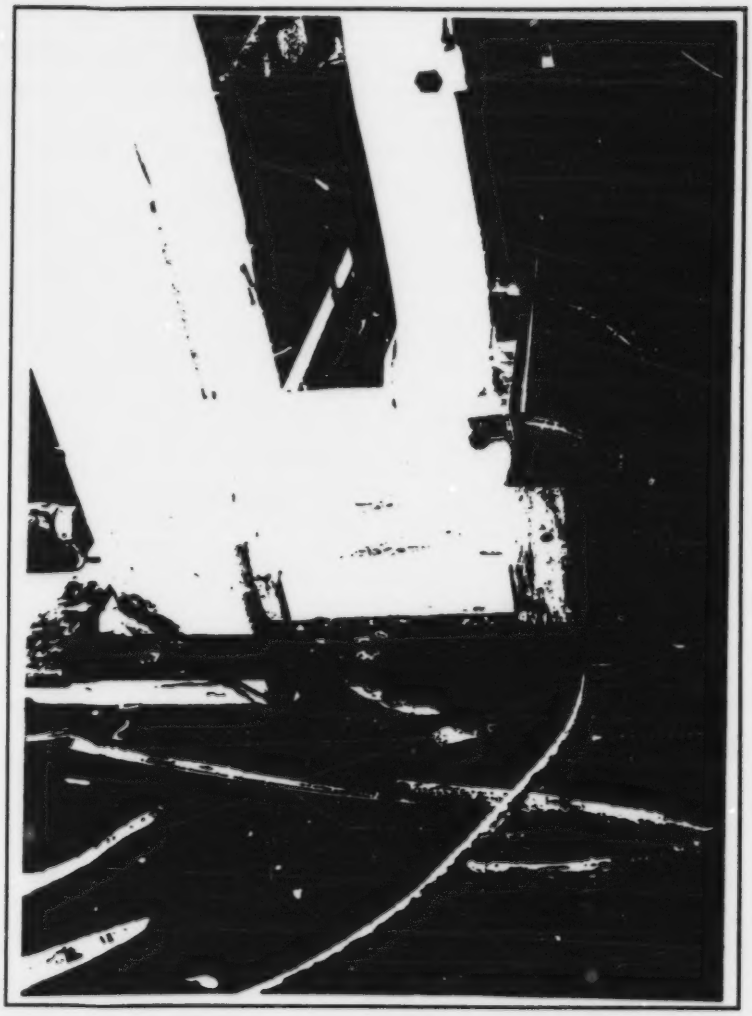


Notes: Grout line length approximately 35 feet. 3/8" OD flexible polyethylene tubing used to inject epoxy.

A total of five 4 L units of Capweld 624LE and one 4 L unit of Capweld 624 thixotropic used to inject model.

FIGURE A7

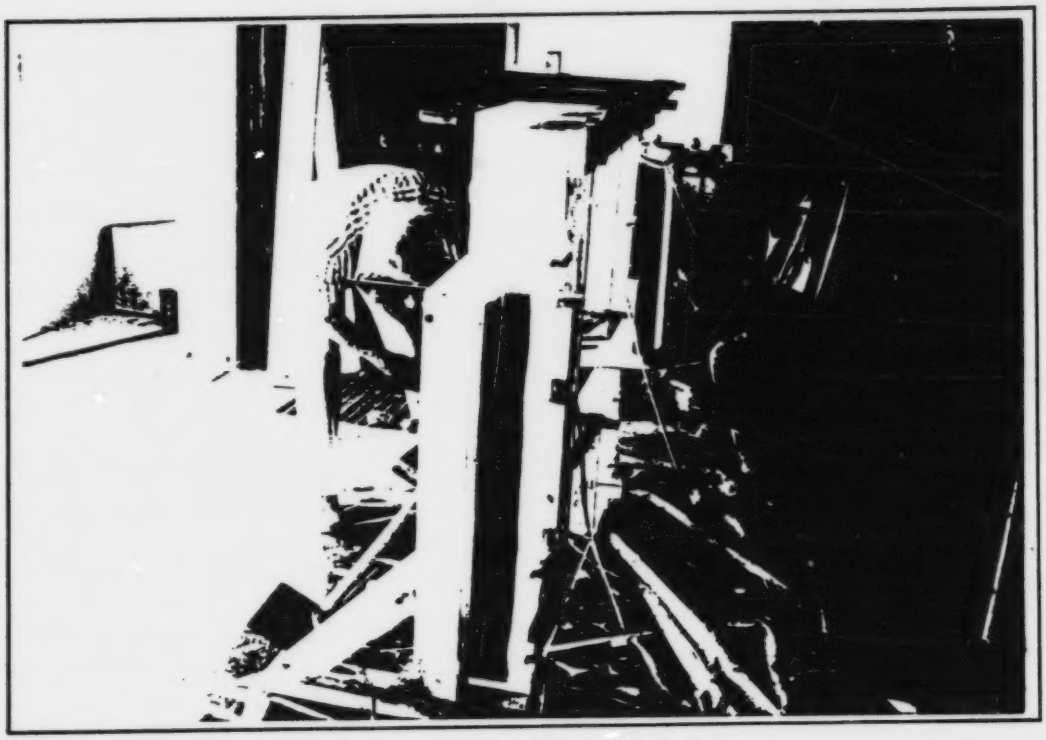
EPOXY INJECTION OF FULL-SCALE SIMULATED MODEL OF SFSB/SFTD BULKHEAD MODEL 1



Epoxy injected into base to create a dam on the north and south walls

FIGURE A8

INJECTION OF CAPWELD 624 THIXOTROPIC



Epoxy injected to fill void along walls and roof

FIGURE A9

INJECTION OF CAPWELD 624 LE LOW VISCOSITY EPOXY

APPENDIX B

Full-Scale Model of SFSB/SFTD Bulkhead and Tunnel Model 2

1.0 Construction and Epoxy Injection of Bulkhead

The full-scale model of the simulated steel bulkhead and tunnel is shown in Figures B1 to B3. The location of injection ports and vent tubes is shown in Figure B4. The procedures followed to construct the temporary seal around the bulkhead and to epoxy inject the void are similar to those used for Model 1.

Table B1 and Figure B5 summarize the notes taken during the epoxy injection. The time to fill the complete void was 201 minutes. Injection pressure at the pressure pot was 80 psi.

The epoxy easily flowed into the void and displaced the water. Where the epoxy was allowed to free-fall through the water, stratification, emulsification and segregation occurred. After completion of the epoxy injection, a hydraulic head of 10 ft was maintained for 72 h to assess the integrity of the repair.

TABLE B1
EPOXY INJECTION OF SIMULATED SFSB/SFTD MODEL
(See Figure B5 for further details)

Material	Batch Number	Mixing Time A & B Epoxy components (min)	Time to fill Pressure Pot (s)	Time to fill 3/8" rigid Tubing (s)	Injection Time (min)	Location	Injection Pressure (psi)/1/	Measured Height of Epoxy in Model (in)	Remarks
Capweld 624LE	1	3	45	35' - 470	0	Port 1 South	80	-	Epoxy injection commenced from port 1 at base of south side.
	1	-	-	-	14	Port 1 South	80	5	
	1	-	-	-	32-1/2	Port 1 South	80	9.5	Stopped to dump batch 1 in pressure pot and mixed batch 2.
	2	3	60	13' - 110	39	Port 3 South	80	18.5	Epoxy injection carried out from port 3.
	2	-	-	-	50	Port 3 South	80	31	
	2	-	-	-	59	Port 3 South	80	40	-
	2	-	-	-	73	Port 11 North	80	8	Stopped to move to port 11 north side.
	2	-	-	-	82	Port 11 North	80	16	-
	2	-	-	-	89	Port 11 North	80	21	-
									Stopped to dump batch 2 in pressure pot and mixed batch 3.
	3	3	60	13' - 115	96	Port 11 North	80	26	-
	3	-	-		107	Port 11 North	80	31-1/2	Stopped to dump batch 3 in pressure pot and mixed batch 4.
	-								
	4	3	50	13' - 100	123	Port 9 North	80	36	-
	4	-	-	-	129	Port 9 North	80	42	-
	4	-	-	-	144	Port 9 North	80	46-1/4	1/4" layer flowed approx. 32" across surface of roof.
					145	Port 9 North	80	-	Stopped to dump batch 4 in pressure pot and mixed batch 5.
	5	3	50	13' - 115	151	Port 7 Roof	80	-	Epoxy injection carried out from port 7 on roof.
	5	-	-	-	172	Port 7 Roof	80	1/2" thick layer across roof	
					184	Port 7 Roof	-		Stopped to dump batch 5 in pressure pot and mixed batch 6.
	6	3	45	-	201	Port 7 Roof	80	-	Model completely filled with epoxy resin.

/1/ Injection pressure measured at pressure pot.

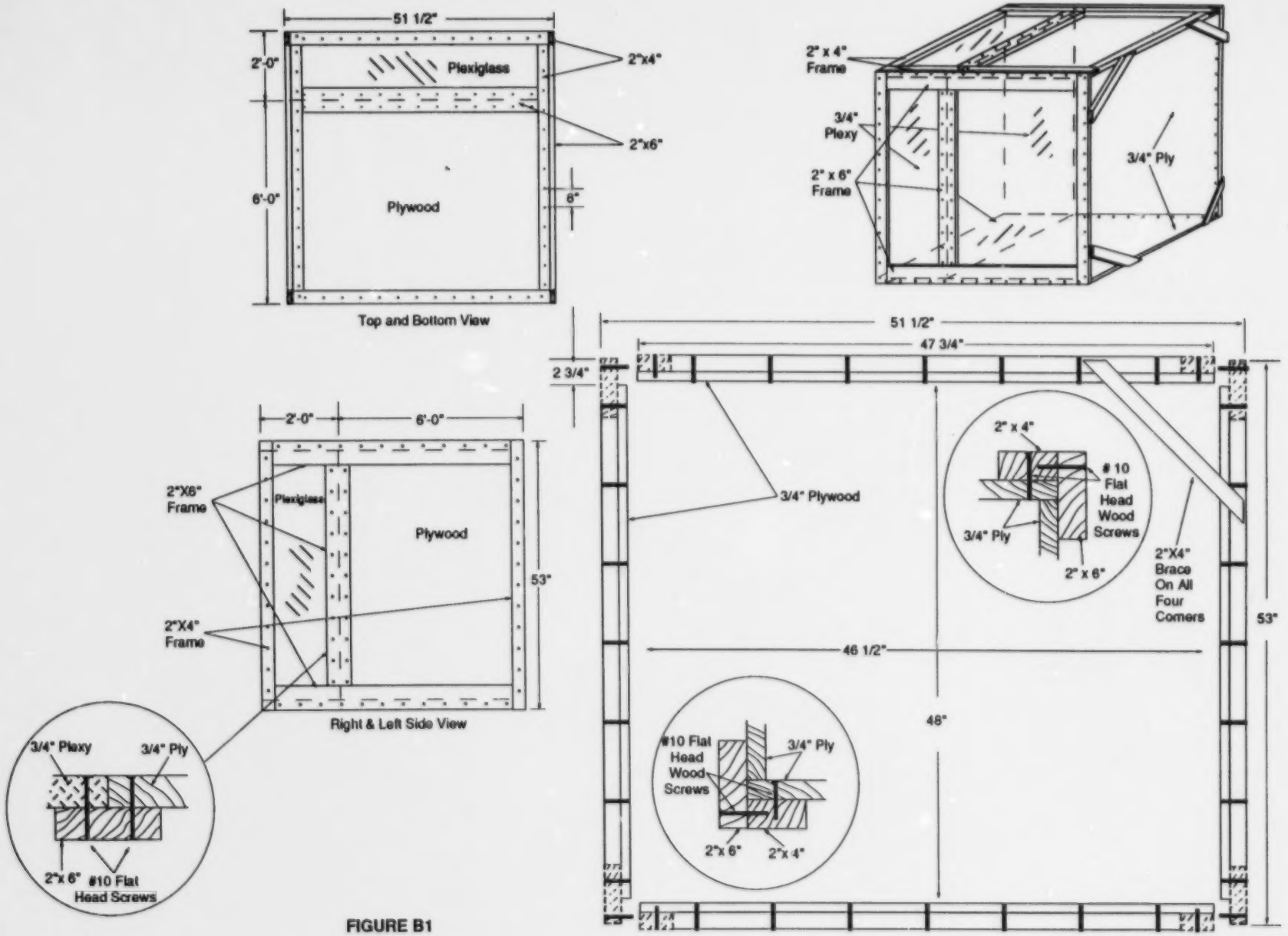


FIGURE B1

FULL SCALE MODEL OF BULKHEAD SEPERATING SPENT FUEL STORAGE BAY AND SPENT FUEL TRANSFER DUCT

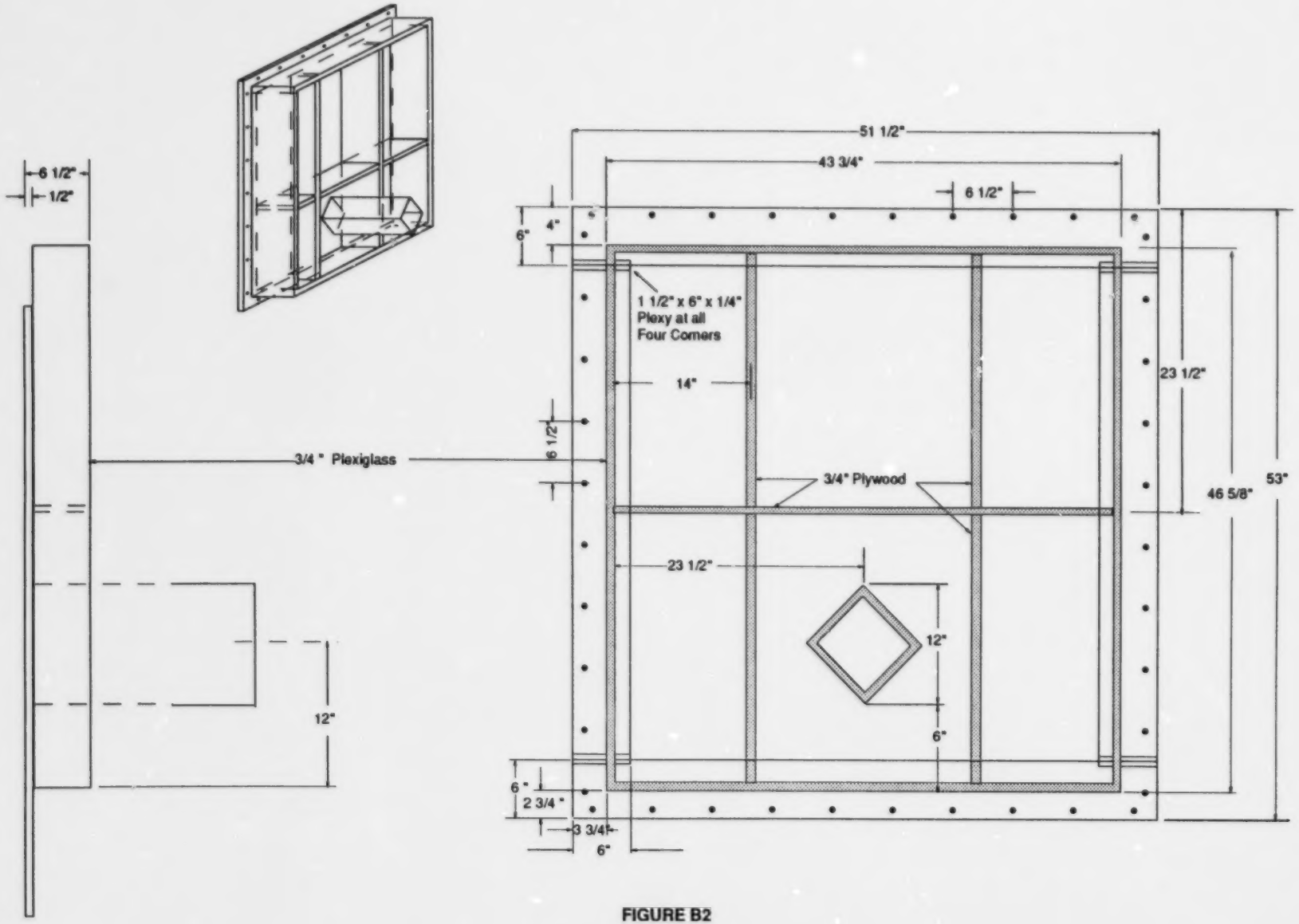
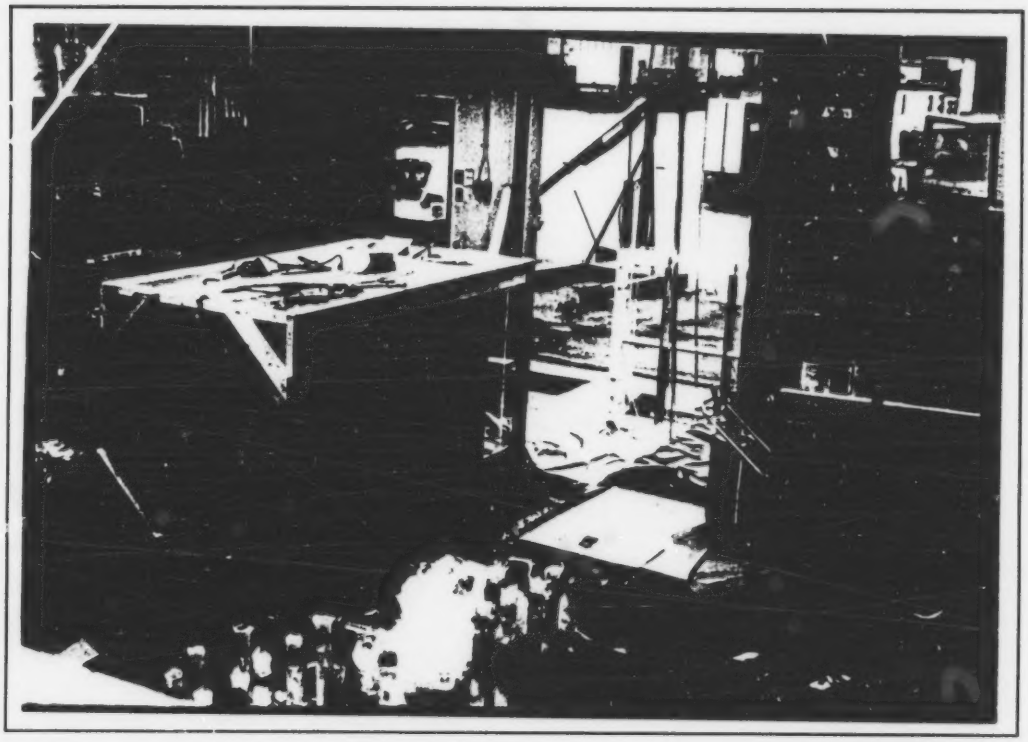
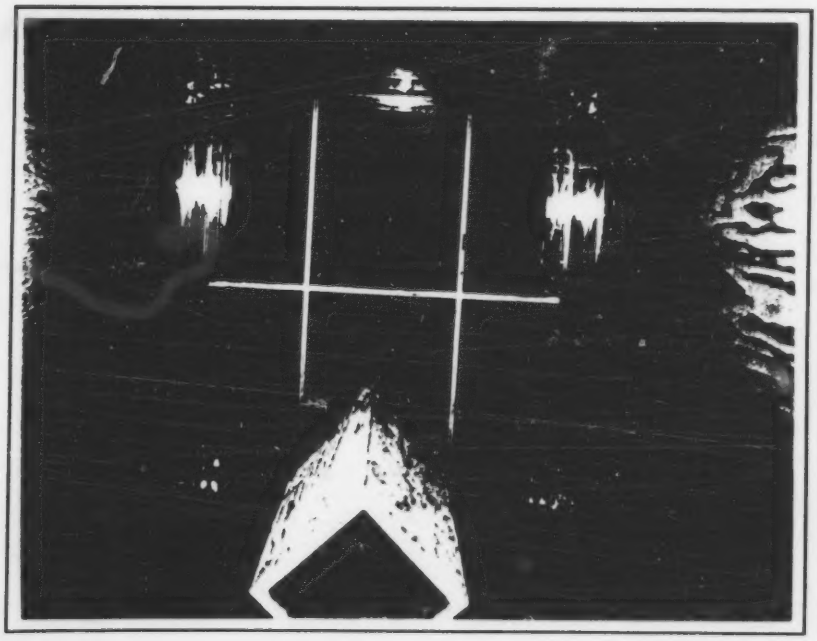


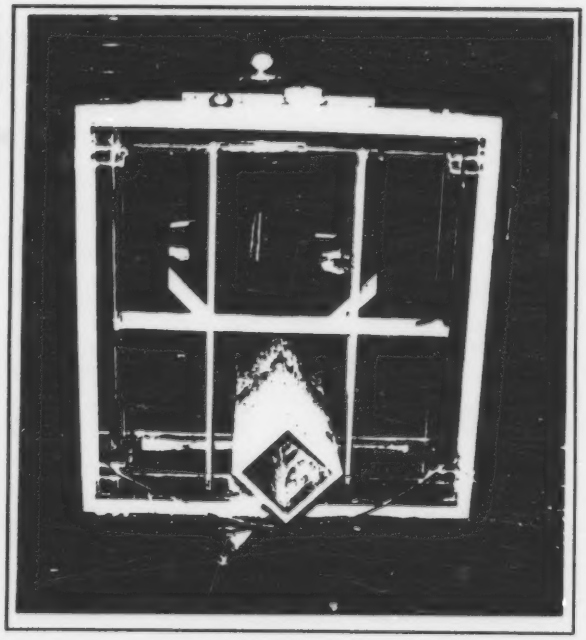
FIGURE B2

FULL SCALE MODEL OF BULKHEAD SEPERATING SPENT FUEL STORAGE BAY AND SPENT FUEL TRANSFER DUCT





View of bulkhead from SFTD tunnel



View of bulkhead from SFSB side

FIGURE B3

FULL-SCALE MODEL OF SFSB/SFTD BULKHEAD AND TUNNEL

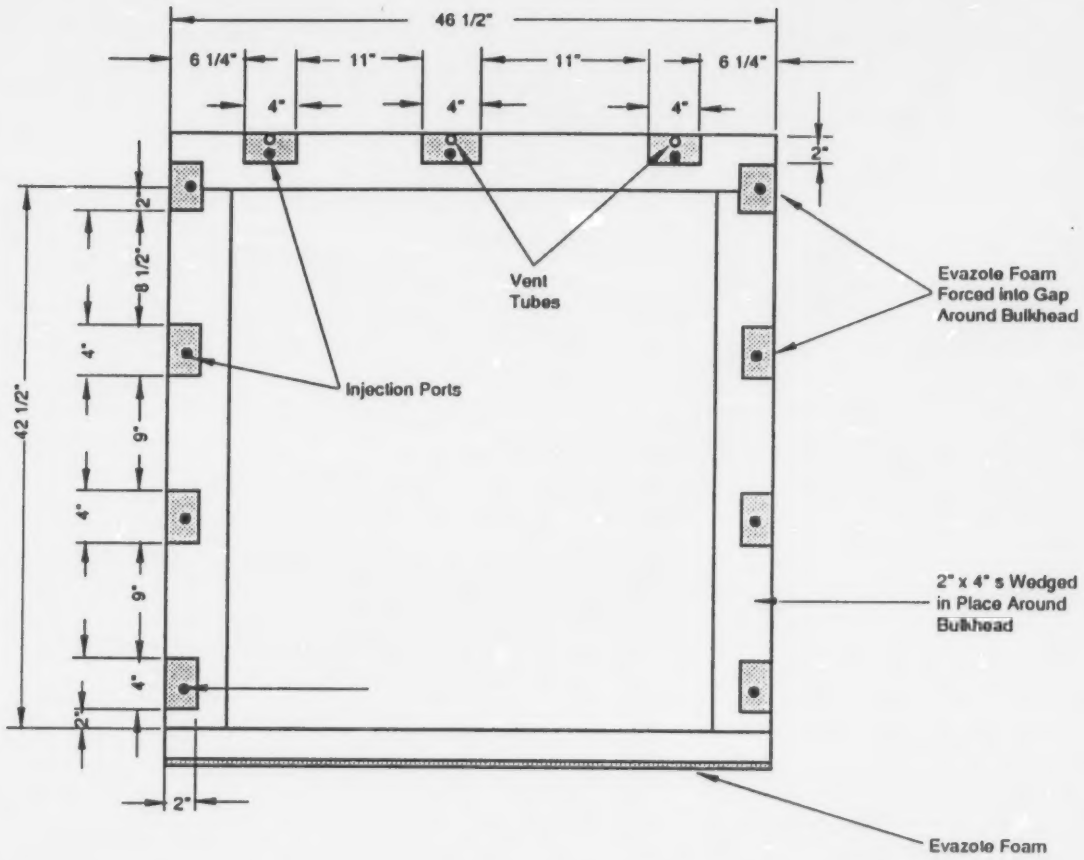
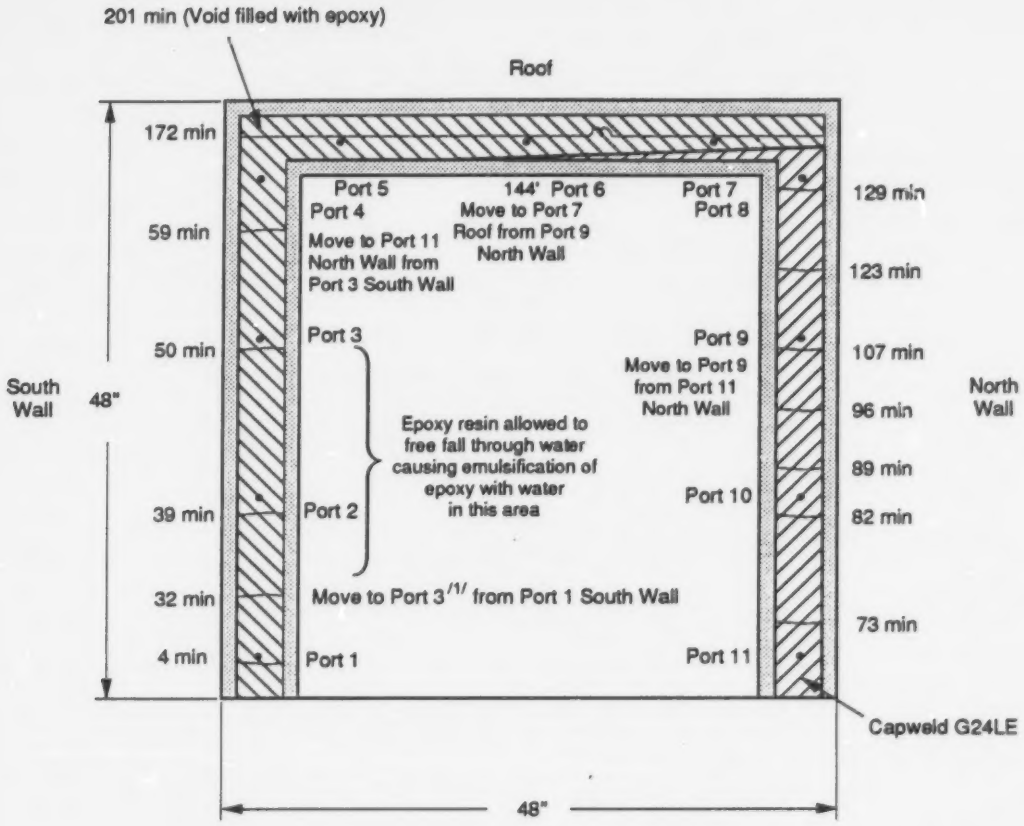


FIGURE B4

DIAGRAM OF INJECTION PORT PLACEMENT IN 2" X 4" FRAME



Notes: Grout line reduced from 35' to 15' to speed up injection process. 3/8" rigid polyethylene tubing used to inject epoxy.

A total of six 4 L units of Capweld 624LE epoxy were used to epoxy inject model (actual size of void filled by epoxy 1-3/8" x 4" x height or length).

FIGURE B5

EPOXY INJECTION OF FULL SCALE SIMULATED MODEL OF SFSB/SFTD BULKHEAD MODEL 2

APPENDIX C

Recommended Repair Procedures

APPENDIX C

PROCEDURE FOR REPAIRING
WATER LEAKAGE BETWEEN
SPENT FUEL STORAGE BAY
AND SPENT FUEL TRANSFER DUCT

MATERIALS

Table C1 identifies all the necessary materials required to complete this repair.

PROCEDURE

Step 1

A. Once access is gained to the SFTD, Construction will accurately measure the dimensions of the tunnel at the bulkhead, as well as the actual gap between the concrete and stiffener plates on the bulkhead at the north and south walls, and the roof.

B. Measure the distance between the north and south walls of the duct near the sump. This is necessary so that a 4" x 4" wood bracing can be installed to create a dam and prevent any epoxy entering the sump in case of leakage during injection.

Step 2

A. Pre-cut closed cell polyethylene foam to fit into the gap between the stiffener plates of the steel bulkhead and concrete surface (Figure C1) on the north and south walls and roof of the duct.

B. Weld sections of foam together using splicing tool.

C. Cut slots in foam at locations identified in Figure C2, and heat ⅜" metal rod to perforate foam at these locations in order to install injection ports. Three vent tubes should also be installed through the foam along the top of the roof (Figure C2). Install injection ports through foam. Vent tubes are to be placed through the foam after installing the foam.

Step 3

After installing the foam, measure exact location of injection ports and vent tubes. Pre-cut wood bracing to friction fit between the walls and roof of the duct in front of foam (Figure C3). Glue ½" x 3½" and ½" x 1½" foam to side and base of wood. Use Capbond Ex-grey epoxy to bond foam to wood. Allow material to harden. Drill holes (ie, to match location of injection ports and vents) through wood and foam to accommodate polyethylene tubing which is connected to injection ports and vent tubes. These holes are required for the wood bracing which is to be installed along the north and south walls and roof of the duct.

Along the base of the duct, no holes are required through the wood bracing as this bracing will be used to seal any gap between the concrete and stiffener plate.

Step 4

Pre-cut 4" x 4" bracing to accommodate installation of a dam near the sump. Install ½" x 3½" foam on the underside and ends of the wood using Capbond Ex-grey epoxy.

Step 5

Install polyethylene foam (ie, along walls and roof) by compressing the foam and forcing it into the space between the concrete and stiffener plates.

Install vent tubes (Figure C2) so that they are in contact with the roof of the duct.

Place polyethylene tubing through holes in wood bracing and connect and clamp to injection ports and vents. Friction fit wood bracing on the north and south walls and roof. Friction fit wood bracing along the floor by first applying Capbond Ex-grey epoxy to underside of the foam glued to the wood. This is required to ensure that a seal is obtained between the concrete and stiffener plate at the base.

Step 6

Run injection tubing from bulkhead in the SFTD up the manhole to the panel board located at Elevation 254' in the SFSB area (Figure C4). Ensure that all the injection tubing is properly identified for location on the bulkhead (Figure C2) to accommodate epoxy injection.

Step 7

Friction fit 4" x 4" bracing on the floor between the north and south walls near the sump. (Note: Place Capbond Ex-grey epoxy on the bottom of the foam bonded to the wood prior to installing.)

Step 8

Install video camera (with additional lighting) into the SFTD. Run cables to Elevation 254' and connect to monitor. Turn video camera on and focus camera to view complete bulkhead area.

Step 9

Epoxy Injection of Void.

A. Separately mix A&B components of Capweld 624 LE epoxy. Combine together and mix for a minimum of 3 minutes.

B. Pour premixed material into pressure pot, close lid, and then connect air line to the pressure pot. Note that whenever pressure pot is to be refilled with epoxy, the air line should be disconnected, and air pressure released from the pot through the pressure relief valve.

C. Set line air pressure to 100 psi.

D. Open inlet valve and begin filling injection tube connected to bulkhead with epoxy.

E. The procedure followed for epoxy injection should be carried out in accordance with Figure C2.

F. Keep detailed records (Table C2) of the epoxy injection process.

G. The Capweld 624 LE epoxy should be discharged from the pressure pot within 45 minutes of mixing to prevent setting up of the epoxy.

H. Monitor progress of injection using video camera and by periodically entering duct to visually inspect progress of the work and check for any potential problems.

Step 10

Allow epoxy materials to harden for 24 h. Inspect area to assess the effectiveness of the repair.

Step 11

Remove temporary dam isolating sump. Leave all other bulkheads in place.

TABLE C1

Pickering NGS
Materials Required to Carry Out Repair of
Bulkhead Between the Spent Fuel Transfer
Duct and Spent Fuel Storage Bay

	Material	Manufacturer	Quantity	Use
1.	Closed cell polyethylene foam (Evazote)	Cappar Ltd. (453-5280)	1½" x 2" - 30 ft 1½" x 2" - 30 ft 1½" x 2" - 30 ft 2" x 2" - 30 ft ½" x 3½" - 30 ft ½" x 1½" - 30 ft	To form bulkhead at front of void to accommodate epoxy injection.
2.	High pressure rated polyethylene tubing (rigid - clear) and adapters to connect to pressure pots.	J.J. Downs Cappar Ltd.	¼" diameter - 600 ft 20 adapters to connect tubing to pressure pot	To be able to remotely epoxy inject void and reduce radiation exposure to workers.
3.	Injection ports and clamps for connecting to polyethylene tubing and pressure pots.	Cappar Ltd or specialty built adapters made by construction	24 for installation through polyethylene foam	To accommodate connection of polyethylene tubing to the bulkhead for epoxy injection.
4.	2 - pressure pots with the necessary fittings and adapters to regulate air pressure and control the epoxy injection process.	Cappar Ltd.	2	Used to pressure inject epoxy into void.
5.	Capweld 624 LE epoxy	Cappar Ltd.	12 units (48L)	Low viscosity epoxy used to fill void and seal water leak.
6.	Capbond EX Grey epoxy	Cappar Ltd.	4 units (16L)	Used to bond polyethylene foam to wood bracing, steel and concrete surfaces.
7.	Capbond 624 Thixotropic	Cappar Ltd.	4 units (16L)	Backup epoxy to prevent any loss of epoxy from void during injection.
8.	Wood bracing (2" x 4")	Obtain from stores at station	32 ft	To act as bracing to hold polyethylene foam (ie, Evazote) in place during epoxy injection.
9.	Wood bracing (4" x 4")	Obtain from stores at station	8 ft	To create a dam along the floor of the duct near the sump to prevent any epoxy leaking into the sump.
10.	Methyl Ethyl Ketone (MEK)	Cappar Ltd.	20L	To cleanup tools, pressure pots, etc. during and after epoxy injection/1/.
11.	Plastic mixing containers	J.J. Downs	16 - 8L capacity	To premix A&B components of epoxy.
12.	Trowels, spatulas, rubber gloves	Obtain from stores at station		To apply Capbond Ex-grey epoxy to polyethylene foam.

/1/This material is highly flammable and proper safety precautions should be followed when handling this material. Contact the manufacturer or Pickering Health and Safety for further information.

TABLE C1 (Cont'd)

Pickering NGS
Materials Required to Carry Out Repair of
Bulkhead Between the Spent Fuel Transfer
Duct and Spent Fuel Storage Bay

	Material	Manufacturer	Quantity	Use
13.	Face shields and safety glasses.	Obtain from stores at station		To protect workers in case of line breakage during epoxy injection.
14.	Plastic, tape, etc.	Obtain from stores at station	Area should be approximately 10' x 10' or larger	To provide and maintain a clean laydown area for handling, mixing and placing epoxy materials.
15.	Wooden panel board (located at Elevation 254' in Spent Fuel Storage Bay Area near the hatchway leading into the Spent Fuel Transfer Duct).	Obtain from stores at station	1	To organize and identify the polyethylene tubing lines running from the Spent Fuel Transfer Duct to the Spent Fuel Storage Bay Area. To ensure that the epoxy injection process is carried out in an organized fashion.
16.	Splicing tool.	To be supplied by Civil Research, Concrete Technology Section	1 splicing tool	To weld joint of polyethylene foam together.
17.	Propane torch and ¾" metal rod.		1 - propane torch	Heat metal rod and performate foam to install injection port in foam.
18.	¾" Drill and Power Source.	Obtain from stores at station	1 - drill with extension cords to connect to power source	Used to mix A&B epoxy components separately and then to blend materials together.
19.	Jiffler Mixing Blades.	Builders Tools, Concord (669-2391)	4	Mixing blades attached to drill for mixing epoxy components.
20.	Video camera, cable and monitor.	To be supplied by Pickering Operations	1	To remotely monitor epoxy injection process and reduce radiation exposure to workers.

TABLE C2

Pickering NGS
Detailed Inspection Notes of Epoxy Injection of SFTD Bulkhead

Material	Batch Number	Mixing Time of A&B Components Start/Finish	Time Mixed Materials Placed in Pressure Pot	Injection Tube Number	Location	Time		Connection of Epoxy with Injection Tube	Remarks
						Injection Starts	To fill Injection Tube and Connect with Bulkhead		

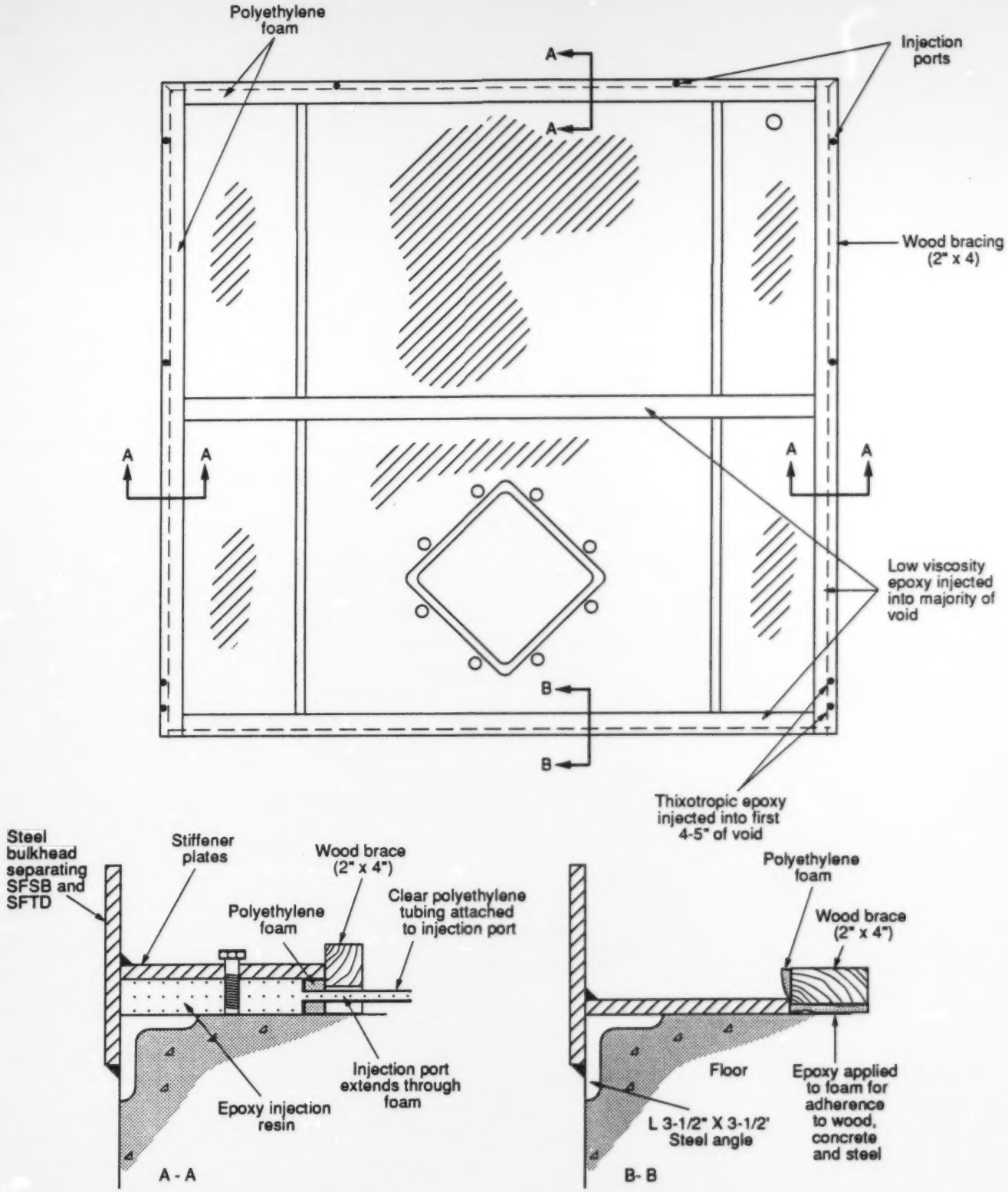
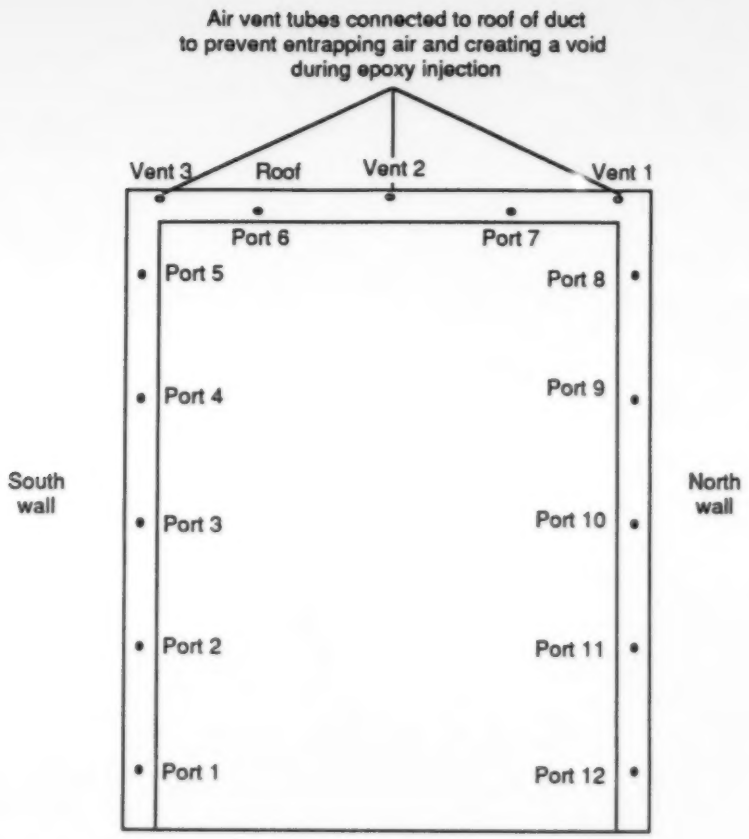


FIGURE C1

RECOMMENDED REPAIR PROCEDURE



A. Commence epoxy injection from Port 1 until resin connects with Port 2.

B. Once epoxy connects with Port 2, disconnect from Port 1 and connect with Port 2. Continue epoxy injection in a similar procedure until epoxy connects with Port 5.

C. Once epoxy connects with Port 5, stop and connect to Port 12; then, commence epoxy injection process following same steps as above.

D. Continue epoxy injection until resin exits vent 3 along roof.

E. Once epoxy exits vent 3, reduce injection pressure to 20 psi and hold for a minimum of 5 minutes.

FIGURE C2

LOCATION OF INJECTION PORTS AND PROCEDURES FOR REPAIR

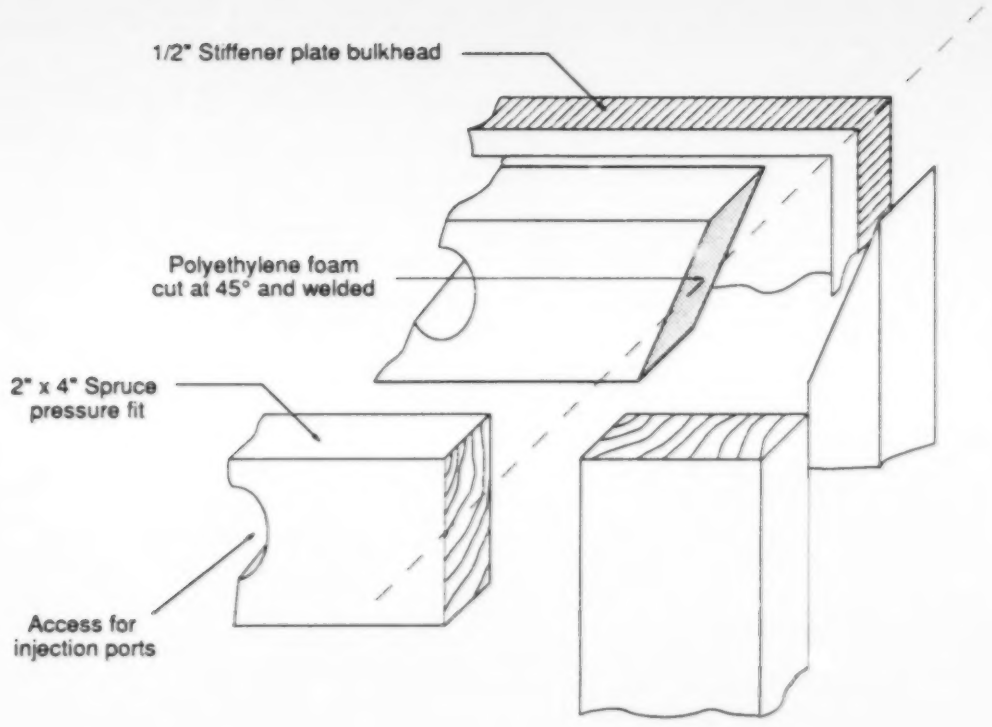


FIGURE C3

**DETAILS OF CONSTRUCTION BULKHEAD
FOR EPOXY INJECTION OF VOID**

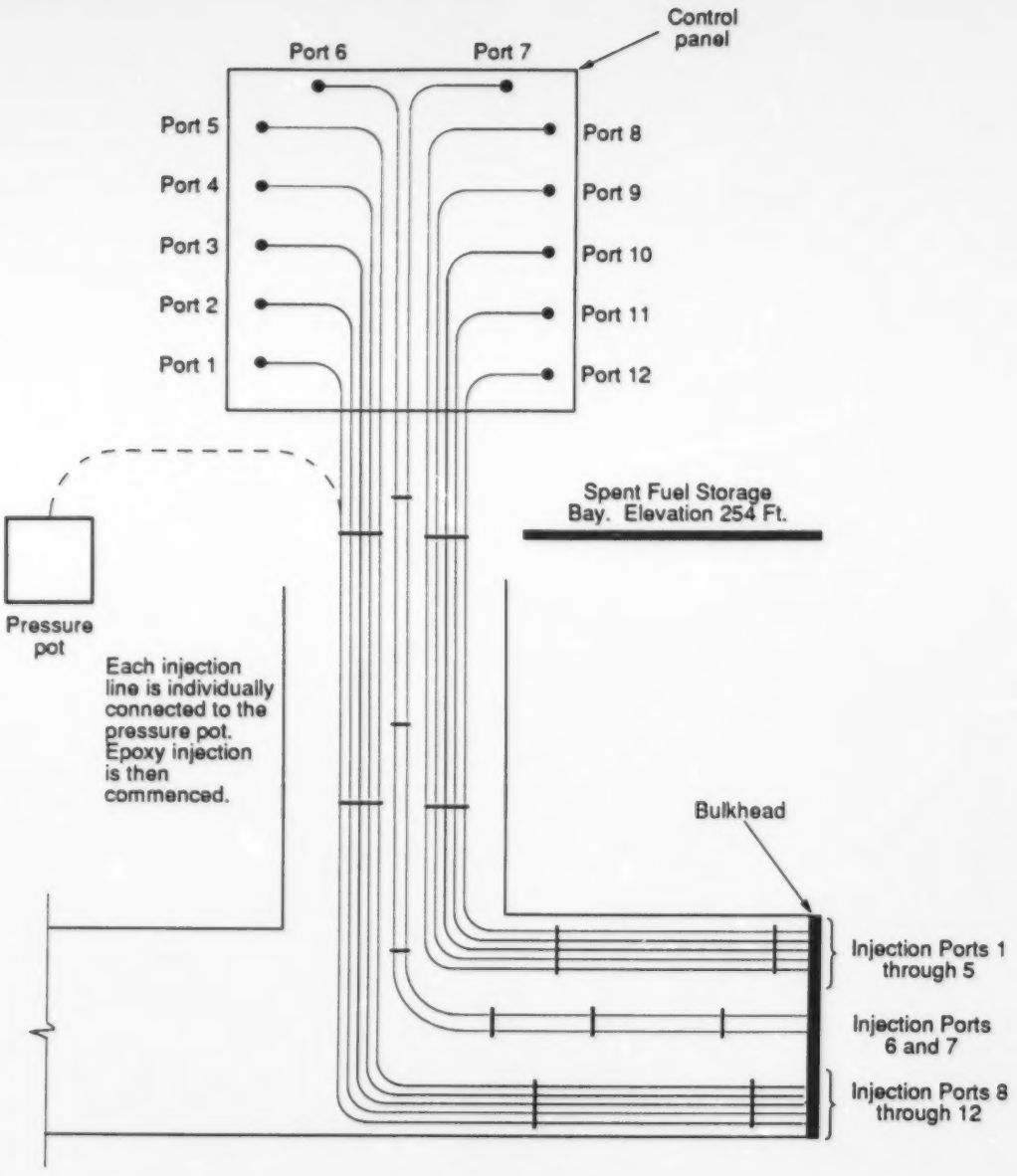


FIGURE C4

SCHEMATIC OF EPOXY INJECTION PROCESS

184243-C18-RD